# VISUAL PROBLEMS of School Children

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## Contents


| Part | | Page |
|---|---|---|
| I. | Introduction | 1 |
| II. | Near Point of Convergence | 5 |
| III. | Visual Acuity | 7 |
| IV. | Interpupillary Distance | 10 |
| V. | Ocular Motility | 11 |
| VI. | Symptoms | 14 |
| VII. | Pathology | 17 |
| VIII. | Stereopsis | 21 |
| IX. | Fusion | 24 |
| X. | Ametropia | 27 |
| XI. | Retinoscopy | 33 |
| XII. | Relationship Between Retinoscopic F | 37 |
| XIII. | Manifest, or Basic Formula | 40 |
| XIV. | Analysis Sequence | 45 |
| XV. | Subjective, or Manifest, at Near Poin | 48 |
| XVI. | Ductions | 51 |
| XVII. | Phorias | 59 |
| XVIII. | Amplitude of Accommodation | 64 |
| XIX. | Relative Accommodation at Near Poi | 66 |
| XX. | Cycloplegic Findings | 68 |
| XXI. | Incidence of Previous Corrections | 70 |
| XXII. | Summary and Conclusions | 72 |
| XXIII. | Approaches to the Study of Vision F | 75 |
| | Appendix | 79 |

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# Visual Problems Of School Children

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## Part I

### Introduction*

This is the first of a series of articles dealing with the seeing problems of elementary school children. The data have been collected on children at the fifth grade level. These and other data on vision are being reported in a number of master's theses and doctor's dissertations in the Graduate School of The Pennsylvania State College.

#### Purposes of the Study

The chief purpose of these studies is to inventory seeing needs in public schools. The specific purposes include:

1. To define certain visual problems of children.
2. To determine the incidence of certain seeing and ocular conditions among the school population.
3. To secure an appraisal of both near-point and far-point problems.
4. To study the distribution of findings on each test item in a comprehensive visual analysis.
5. To inventory symptoms of seeing difficulties and ocular discomfort.
6. To study relationships between reported symptoms and performance on the visual analysis tests.
7. To study the relationships among certain visual analysis findings.
8. To study the relationship between achievement in reading, in terms of mental ability, and performance on visual analysis findings.

#### Justification

In the visual surveys of school children which have been reviewed, one of the outstanding limitations was the type of examination used. There appears to have been an overemphasis on these items: visual acuity at twenty feet, gross "muscle defects," and pathology. If the child "passed" these, he was given "a clean bill of health for his eyes." If he had headaches, blurred vision, and the like, but no "refractive error," he continued on his uncomfortable way with no further consideration.

In the studies reported, few psycho-physiological findings were taken. In this investigation, it will be noted that a much more comprehensive study of vision was made.

In almost every instance investigators agree that there seems to be a relationship between visual findings and readiness for sustained attention in reading activities, though some studies fail to demonstrate it. Clinical data show conclusive evidence that there is a relationship and indicate the need for more complete visual analysis in future investigations. Witty and Kopel comment: "Studies

*Special acknowledgements are due to several professional workers. All office examinations in connection with the study made in Huntingdon, Pennsylvania, were taken by Dr. William T. Hunt, Jr. (M.D.). Bonnalee Brown, Reading Clinic Assistant at the Pennsylvania State College, assisted with the administration of the Betts Tests, the reading tests, and the intelligence tests. Dr. A. M. Skeffington generously gave time to planning the study and to interpreting the results. Dr. Carl F. Shepard has been a source of inspiration and help. A. Sterl Artley, Reading Clinic Assistant, Dr. Arthur Ayers, Reading Clinic Statistician, and Dr. H. Arthur Meyer have assisted with many of the statistical problems.

Special acknowledgment is due to Superintendent Eberhardt of Huntingdon, Pennsylvania. Through his leadership and earnest desire to make a scientific study of some of his problems, this study was made possible.

The writers wish to express their appreciation to Miss Dorothy Lesh, Reading Clinic Secretary, who was responsible for the accuracy of the final manuscripts. Without her assistance, they would have been seriously handicapped in their efforts to report these data.

of individual cases with marked visual defects which have been corrected or ameliorated, and followed by appropriate remedial procedures, generally show definite improvement in reading attainments."[57]

It does not appear reasonable to investigate visual acuity at distance and to expect to find a relationship between this finding and scholastic aptitude (or reading achievement) at near point. Most previous investigations of school populations have been done at twenty feet. It appears that something more than "refractive errors" are involved in this vision-reading relationship. It was expected that this investigation of a number of additional factors included in the more comprehensive term "visual efficiency" would yield data which would permit a better understanding of the problem.

In brief, this study was made for two reasons: First, to apply for the first time a technique of examination based upon a psycho-physiological concept of seeing. Second, to study the relationship between the findings taken and reading achievement.

### Limitations

Some of the limitations of this study follow:

1. One hundred and twenty-six children, the entire fifth grade population of the Huntingdon, Pennsylvania, Public Schools, were used as subjects. Complete data were secured on 109 cases.

2. The average chronological age was 11 years 1.5 months; the range, 10-0 years to 14-5 years.

3. The average IQ was 104.2, S.D. 14.1; the range, 63 to 137.

4. The data were collected in March, April, and May, 1940.

5. The tests administered were:

a. The Gates Reading Survey for Grades 3 to 10, to measure achievement in reading.

b. The California Test of Mental Maturity, to measure intelligence.

c. Visual tests:

(1) The Visual Sensation and Perception Tests of the Betts Ready to Read Battery.

(2) The Analytical Visual Routine Examination, otherwise known as the Twenty-one Point Examination.

(3) Retinoscopic and subjective examination of the refractive condition under cycloplegia.

d. An Inventory of Symptoms.

6. Instruments Used:

a. Two Keystone Telebinoculars and two sets of unused Visual Sensation and Perception Test slides.

b. Greens' Refractor, American Optical Company Projector Chart, an aluminum screen, DeZeng Polaroid Ophthalmoscope, and a Copeland Streak Retinoscope.

7. Test Cards Used:

a. To check visual acuity:

At distance: Projected Snellen type at twenty feet. Visual acuity cards of the Betts Battery.

At Near Point: The American Medical Association Reading Test Card at 14 inches.

b. For the Analytical Routine:

At 20 feet: Projected Snellen type.

At 16 inches: Reduced Snellen type. Farmer's Grid for Cross-cylinders.

8. The Visual Sensation and Perception Tests were administered by two experienced examiners.

9. The Visual Sensation and Perception Tests were administered in a room in each school building from which direct daylight was excluded.

10. The analytical routine and the cycloplegic examinations were administered by Dr. William T. Hunt, Jr. (M.D.), in his office at Huntingdon, Pennsylvania.

11. The children wearing corrections (glasses) were examined on the Telebinocular first without their correction and then with it.

12. Visual acuity was checked on the Snellen chart first without glasses and then with glasses if a correction was worn.

13. Two tests, Number 3 and Number 13A, in the analytical routine were made with the subject's glasses on, if a correction was habitually worn.

14. The reading and intelligence tests were administered by members of the Reading Clinic Staff.

15. The visual analysis routine examination was developed for examining individuals who have binocular vision.

16. The Number 2 finding—the ophthalmometer—was not taken. This finding is the mechanical measurement of the external curvature of the cornea for the purpose of discovering corneal astigmatism. The finding is not used because corneal astigmatism may be compensated for by lenticular astigmatism and because over-all astigmatism is considered in the Number 7 finding.

17. No recording was made for astigmatic findings by the use of the retinoscope.

18. Only one formula was used for determining the Reading Quotient:

$$R.Q. = \frac{R.A.}{M.A.}$$

### Procedures

#### Selection of the Population Studied

One hundred and twenty-six children enrolled in the fifth grade of the Huntingdon, Pennsylvania, public schools were selected as the population for this investigation. This population appeared to be fairly typical in terms of socio-economic status. Furthermore, the data presented in this report indicate that it was also a fairly

normal and typical population in terms of intelligence and reading achievement.

### Selection of Tests for This Study

The Gates Reading Survey Tests[29] for Grades 3 to 10 were selected as the basis for securing reading ages because they showed greater discrimination at the upper and lower levels than any other reading test which was administered to a fifth grade population investigated in 1938 by the Reading Clinic Staff of the Pennsylvania State College. The California Test of Mental Maturity[50] was selected but was found to have most of the limitations of a group test of intelligence.

For the purpose of securing a subjective report of seeing difficulties and ocular discomfort, a questionnaire which is identified as the "Symptoms Inventory" was given to each member of the group.

Three types of vision tests were administered to each subject for the purpose of investigating all aspects of the seeing process. The Visual Sensation and Perception Tests of the Betts Ready to Read Battery[10] were selected as the most complete and satisfactory screening battery for the identification of children who should be referred to the eye specialist for a complete visual analysis. For a complete visual examination, the Analytical Visual Routine[18] was decided upon as being the most thorough method based upon a psychophysiological concept of seeing. And, too, it is a widely used analytical routine. A cycloplegic examination, routinely employed by medically trained examiners, was made to identify intra-ocular pathological conditions and as a refractive procedure.

The analytical visual routine examination consists of twenty-one primary findings and certain supplementary findings. Groupings of these findings, called syndromes, indicate different situations in the relationship between accommodation and convergence and serve as guides for the correction of faulty or inadequate relationships.

### Administration of Tests

The tests were administered in the following order:

1. The reading test
2. The intelligence test
3. The symptoms inventory
4. Betts Visual Sensation and Perception Tests
5. The analytical visual routine
6. The cycloplegic examination

All tests were completed during March, April, and May, 1940.

The symptoms inventory was presented in a group situation. Each part of the questionnaire was explained and discussed, and the subjects given time to answer each question immediately after the discussion.

The Visual Sensation and Perception Tests were administered according to the instructions described in the 1936 Manual[10] with one exception. Upon the recommendation of the author of the tests, all far-point tests were taken with the slide holder set at +0.50 on the shaft.

The analytical visual routine examination was made by Dr. William T. Hunt, Jr., an ophthalmologist, in his office in Huntingdon, Pa. The technique and targets used were those recommended by Dr. A. M. Skeffington[47] and detailed in Dvorine's Manual.[18] The cycloplegic examination was also made by Dr. Hunt at some time after the analytical routine. The period between the two examinations varied from a few days to a month.

### Definition of Terms

*Achievement in Reading:* "Achievement in reading is a term used in this report to indicate reading performance experienced in terms of mental capacity." (After Bird.)

*High Achievers:* Those subjects whose reading quotients are among the highest twenty-five per cent (109-123 inclusive).

*Low Achievers:* Those subjects whose reading quotients are among the lowest twenty-five per cent (71-97 inclusive).

*Referral:* A term used to indicate that a subject shows the need of a complete visual analysis.

*Non-referral:* A term used to indicate that the subject's performance on screening tests did not indicate the need for further visual care.

*Expected:* A finding established as a guide for each visual analysis test.

*Phoria:* A measurement of the latitude of one visual function while the other function is held fixed. (After Lesser.)

*Duction:* A signal of the degree of interference in brain between the two reflexes: accommodation and convergence. (After Skeffington.)

*Area of Tolerance:* The range within which adjustment may be made by the brain to maintain single vision and clear vision. (After Skeffington.)

*Visual Reflex:* A learned association between accommodation and convergence. (After Skeffington.)

*Inhibit:* To change postural set, by plus lenses or prism base in, as though the stimulus object had been moved farther from the eyes. (After Skeffington.)

*Stimulate:* To change postural set, by minus lenses or prism base out, as though the stimulus object had been moved nearer to the eyes. (After Skeffington.)

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# Part II

## Near Point of Convergence

Near point of convergence is variously referred to as amplitude of triangulation (7), convergence near-point (3, p. 287), or absolute convergence (5, p. 1188). This test is frequently called the "push-up" test. Zoethout (10, p. 287) defines near point of convergence as "the nearest point of light that can be seen singly by the greatest possible convergence." Southall (9, p. 214) refers to this as a state of *dynamic convergence.* It provides an index to the ability of the individual to triangulate while both adduction and accommodation are functioning. The inter-play between focus and triangulation is unhampered. This is one near-point finding that is useful for *screening* as well as for *diagnostic* purposes. Since educators, school psychologists, and industrial psychologists are becoming increasingly sensitive to near-point vision problems, it is reasonable to expect the eye specialist to include near-point tests in his examination. Near point of convergence should be one of those tests.

The term "near point" requires definition in each contextual situation. For example, some authors refer to a given reading distance as near point, others to the near point of accommodation or to the near point of convergence. Atkinson (1, p. 121) refers to punctum proximum as the near point. Duke-Elder (4, p. 144) uses punctum proximum in speaking of both near point of convergence and near point of accommodation. Near point of convergence should not be confused with near point of accommodation.

To summarize, the following terms are used in the study of convergence:

1. Near point of convergence: the nearest point to which a small target can be moved toward the eyes of an individual before diplopia is experienced.
2. Amplitude of convergence: the difference between far point of convergence and near point of convergence, expressed in meter angles (M.A.) or in prism diopters (△). The unit of convergence is the meter angle.
3. Range of convergence: the distance between the near point and the far point.
4. Relative convergence: the amount of convergence possible at a given point without changing accommodation. Positive relative convergence is determined by adding base out (adduction) to *blur;* negative relative convergence, base in (abduction) to *blur.*

### Test Materials

Near point of convergence findings for this study were taken by the use of a transilluminator light (lighted dimly) and a millimeter rule. In the Reading Clinic a standard fountain-pen type Ever Ready flashlight is used. Any small fixation target, such as a pencil point, may be used. A dimly lighted retinoscope bulb makes an excellent fixation target and appears to be used widely.

### Administration of Test

The subject is requested to fix on the light as it is held about sixteen inches from the bridge of the nose. One end of a centimeter ruler is placed against one side of the nose at the anterior focal plane. Then the light is moved along the ruler toward the bridge of the nose until the light reflex is observed to move from the center of one cornea. The reading, in centimeters, is taken directly from the ruler. In this study, a reading was taken by having the subject tilt his head back. Experience in the Reading Clinic indicates the desirability of further study on the need for taking readings when the target is brought to the bridge of the nose from the angle at which reading material is held.

Duke-Elder states (4, p. 144) "Theoretically the distance should be measured from the line joining the centres of rotation of the two eyes (*the base line*), but in practice it is measured from the anterior principal focus, and an average correction of 25 mm. is added on the measurement found."

During the administration of the test, several observations are made: First, the distance from the focal plane at which diplopia is reported. When the light reflex moves from the center of one cornea, diplopia normally is experienced. Without presenting data, Charles H. May comments on the

interpretation of this finding (6, p. 423): "This point should not be more than 75 mm. from the anterior focal plane of the eye (the plane on which spectacles are worn). Any persistent remoteness of the near point of convergence denotes a weakness of that power." Duke-Elder (4, p. 144) states: "Normally it should be possible to maintain convergence when the object is about 8 centimeters away." Southall (9, p. 214) points out that "the near point of convergence is usually considerably closer than the near point of accommodation, being frequently not much more than about three inches from the eyes." (Dr. Luther C. Peter (2, p. 879) suggests: "The near point of convergence expressed in centimeters may be converted into meter angles of convergence by dividing 100 by the number of centimeters. For example, if the near point of convergence is 12.5 centimeters the meter angle of convergence is 8."

Second, eye preference. Most individuals will "break," or experience diplopia, before the light is brought to the bridge of the nose. The dominant eye will continue fixing on the light, while the non-dominant eye usually turns the visual axis away from the fixation target.

Third, suppression. Some individuals may report no diplopia. They should be checked further for suppression.

Fourth, regularity or smoothness of convergence. Single binocular vision should be experienced to the break point.

Fifth, pupillary contraction. Since both focus and triangulation are functioning, the pupils should contract as the fixation object is moved toward the bridge of the nose. As the target is moved closer to the eyes of an individual with normal seeing patterns, more accommodation is called into play and the diameter of the pupil becomes smaller.

### Results of the Study

The distribution of the findings on near point of convergence is presented in Table I. The mean was 4.79 cm.; the range, from 1 to 20 cm. Variations from this mean may be expected for groups at other age levels. Establishment of tables of expecteds requires further investigation.

### Summary

The relationship between near point of convergence and other findings taken in this study will be presented in subsequent publication. A summary of this phase of the study follows:

1. The near point of convergence is studied for the following reasons:

   a. Convergence is normally associated with accommodation in binocular vision. The near point of convergence finding provides evidence of interference in the binocular functions.

   b. The near point of convergence finding provides an index to the integrity of basic visual skills.

2. Approximately 10 per cent of the cases showed a near point of convergence beyond 8 centimeters; 12.5 per cent, beyond 7 centimeters. In view of this, it appears that a substantial percentage of the school population can be referred on the basis of this one finding.

3. For these cases, the *mean near point of convergence* was 4.79 centimeters. Most of the cases achieved close to the mean.

TABLE I

**Distribution of Findings on Near Point of Convergence (Huntingdon, Penna., Data)**

| cm. | f | per cent |
|---|---|---|
| 20.0 | 1 | 0.8 |
| 19.5 | 0 | 0.0 |
| 19.0 | 0 | 0.0 |
| 18.5 | 0 | 0.0 |
| 18.0 | 0 | 0.0 |
| 17.5 | 0 | 0.0 |
| 17.0 | 0 | 0.0 |
| 16.5 | 0 | 0.0 |
| 16.0 | 0 | 0.0 |
| 15.5 | 0 | 0.0 |
| 15.0 | 0 | 0.0 |
| 14.5 | 0 | 0.0 |
| 14.0 | 0 | 0.0 |
| 13.5 | 0 | 0.0 |
| 13.0 | 2 | 1.7 |
| 12.5 | 0 | 0.0 |
| 12.0 | 1 | 0.8 |
| 11.5 | 0 | 0.0 |
| 11.0 | 2 | 1.7 |
| 10.5 | 1 | 0.8 |
| 10.0 | 1 | 0.8 |
| 9.5 | 0 | 0.0 |
| 9.0 | 4 | 3.3 |
| 8.5 | 0 | 0.0 |
| 8.0 | 2 | 1.7 |
| 7.5 | 1 | 0.8 |
| 7.0 | 5 | 4.1 |
| 6.5 | 1 | 0.8 |
| 6.0 | 6 | 5.0 |
| 5.5 | 5 | 4.1 |
| 5.0 | 14 | 11.6 |
| 4.5 | 12 | 9.9 |
| 4.0 | 11 | 9.1 |
| 3.5 | 16 | 13.2 |
| 3.0 | 18 | 14.9 |
| 2.5 | 7 | 5.8 |
| 2.0 | 7 | 5.8 |
| 1.5 | 3 | 2.5 |
| 1.0 | 1 | 0.8 |
| Total | 121 | 100.0 |

M. 4.79 cm.
S.D. ±0.25
S.E. of M. ±0.024

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# Part III

## Visual Acuity

Until recently visual acuity at *distance* was considered to be the chief factor in efficient seeing. In both schools and industry, *near* visual acuity now is receiving more consideration along with psycho-physiological factors. While it is important for an individual to see clearly, it also is necessary to see singly and comfortably. In short, visual acuity is only one factor meriting consideration in either a diagnostic or a screening test procedure.

Children with 20/200 vision usually are recommended to a school for the blind. Those with visual acuity between 20/200 and 20/70 are recommended for sight-saving classes, 20/70 being the upper limit. Other conditions, however, may operate to qualify a pupil for a sight-conservation class.

The Snellen Chart is useful for securing an index to *minimum separable.* The three visual efficiency slides of the Betts Ready to Read battery, are used to secure an index to *minimum perceptible with binocular fusion.*

### Naked Visual Acuity

The monocular visual acuity findings for distance without the aid of corrective lenses are summarized in Table I. 28.2 per cent of these cases exhibited less than 20/20 visual acuity in one or both eyes.

TABLE I

**Distribution of Monocular Visual Acuity Findings at Twenty Feet**

| Visual Acuity | Naked Vision with Occlusion — Right Eye f | Right Eye % | Left Eye f | Left Eye % |
|---|---|---|---|---|
| 20/15 | 57 | 47.3 | 64 | 52.8 |
| 20/20 | 40 | 33.2 | 28 | 23.1 |
| 20/25 | 4 | 3.3 | 5 | 4.1 |
| 20/30 | 4 | 3.3 | 3 | 2.5 |
| 20/40 | 2 | 1.6 | 3 | 2.5 |
| 20/50 | 0 | 0.0 | 3 | 2.5 |
| 20/60 | 2 | 1.6 | 2 | 1.7 |
| 20/70 | 2 | 1.6 | 3 | 2.5 |
| 20/80 | 0 | 0.0 | 0 | 0.0 |
| 20/100 | 3 | 2.4 | 2 | 1.7 |
| 20/200 | 6 | 4.9 | 4 | 3.3 |
| 20/400 | 1 | 0.8 | 4 | 3.3 |
| Total | 121 | 100.0 | 121 | 100.0 |

The monocular visual acuity findings at near without the aid of corrective lenses are summarized in Table II. 18.8 per cent of the population had less than 14/14 visual acuity in one or both eyes.

TABLE II

**Distribution of Monocular Vision Acuity Findings at Fourteen Inches**

| Visual Acuity | Naked Vision with Occlusion — Right Eye f | Right Eye % | Left Eye f | Left Eye % |
|---|---|---|---|---|
| 14/14 | 100 | 88.5 | 97 | 85.9 |
| 14/21 | 5 | 4.4 | 3 | 2.6 |
| 14/24.5 | 2 | 1.7 | 3 | 2.6 |
| 14/28 | 1 | 0.9 | 4 | 3.5 |
| 14/35 | 3 | 2.7 | 1 | 0.9 |
| 14/42 | 0 | 0.0 | 0 | 0.0 |
| 14/56 | 1 | 0.9 | 1 | 0.9 |
| 14/89 | 0 | 0.0 | 2 | 1.8 |
| 14/112 | 0 | 0.0 | 0 | 0.0 |
| 14/141 | 1 | 0.9 | 1 | 0.9 |
| 14/178 | .. | .... | 0 | 0.0 |
| 14/224 | .. | .... | 1 | 0.9 |
| Total | 113 | 100.0 | 113 | 100.0 |

28.3 per cent of the population had less than 20/20 visual acuity in one or both eyes at distance and/or less than 14/14 visual acuity in one or both eyes at near. It is interesting to note that approximately 17.7 per cent of the individuals presented near point visual acuity problems. Table III is a summary of referrals on the basis of less than 20/20 and/or 14/14 visual acuity.

TABLE III

**Summary of Referrals on Visual Acuity Tests**

| | f | % |
|---|---|---|
| Non-referral on near and far V.A. | 81 | 71.7 |
| Referral on near and far V.A. | 18 | 15.9 |
| Referral on far point V.A. only | 12 | 10.6 |
| Referral on near point V.A. only | 2 | 1.8 |
| Total | 113 | 100.0 |

### Unequal Visual Acuity

27.3 per cent of the cases evidenced unequal visual acuity at distance. This statement is based on the naked visual acuity findings. Table IV is a distribution of the findings on those cases with equal visual acuity in each eye.

TABLE IV

**Summary of Equal Visual Acuity Findings at Twenty Feet**

| Visual Acuity | f | % |
|---|---|---|
| 20/15 | 72 | 80.9 |
| 20/20 | 10 | 11.2 |
| 20/25 | 1 | 1.1 |
| 20/30 | 2 | 2.5 |
| 20/40 | 1 | 1.1 |
| 20/50 | 0 | 0.0 |
| 20/60 | 2 | 2.3 |
| 20/70 | 0 | 0.0 |
| 20/80 | 0 | 0.0 |
| 20/100 | 0 | 0.0 |
| 20/200 | 1 | 1.1 |
| Total | 89 | 100.0 |

23.2 per cent of the cases evidenced unequal visual acuity at the near point. Table V is a summary of the findings on those cases with equal visual acuity in each eye.

TABLE V

**Summary of Equal Visual Acuity Findings at Fourteen Inches**

| Visual Acuity | f | % |
|---|---|---|
| 14/14 | 93 | 97.0 |
| 14/21 | 1 | 1.0 |
| 14/24.5 | 1 | 1.0 |
| 14/28 | 0 | 0.0 |
| 14/35 | 1 | 1.0 |
| Total | 96 | 100.0 |

**Visual Acuity Through Subjective**

Table VI is a summary of the visual acuity findings through the subjective (the No. 7 finding of Analytical Visual Routine Examination). It will be noted that there were no candidates for sight-conservation classes in this population. One boy had 20/200 V.A. in one eye and one boy and one girl 20/400 in one eye.

TABLE VI

**Summary of V.A. Through Objective**

| | Right | | | | Left | | | |
|---|---|---|---|---|---|---|---|---|
| | Boys | | Girls | | Boys | | Girls | |
| | f | % | f | % | f | % | f | % |
| 20/15 | 48 | 78.7 | 41 | 68.3 | 42 | 69.0 | 38 | 63.3 |
| 20/20 | 12 | 19.7 | 16 | 26.7 | 13 | 21.3 | 17 | 28.3 |
| 20/25 | 1 | 1.6 | 2 | 3.3 | 1 | 1.6 | 3 | 5.0 |
| 20/30 | .. | .... | 0 | 0.0 | 2 | 3.3 | 0 | 0.0 |
| 20/40 | .. | .... | 1 | 1.7 | 1 | 1.6 | 1 | 1.7 |
| 20/50 | .. | .... | .. | .... | 0 | 0.0 | 0 | 0.0 |
| 20/60 | .. | .... | .. | .... | 0 | 0.0 | 0 | 0.0 |
| 20/70 | .. | .... | .. | .... | 0 | 0.0 | 0 | 0.0 |
| 20/80 | .. | .... | .. | .... | 0 | 0.0 | 0 | 0.0 |
| 20/100 | .. | .... | .. | .... | 0 | 0.0 | 0 | 0.0 |
| 20/200 | .. | .... | .. | .... | 1 | 1.6 | 0 | 0.0 |
| 20/400 | .. | .... | .. | .... | 1 | 1.6 | 1 | 1.7 |
| Total | 61 | 100.0 | 60 | 100.0 | 61 | 100.0 | 60 | 100.0 |

**Visual Efficiency Tests**

Table VII is a summary of the findings on the three visual efficiency slides of the Betts Ready to Read battery. These findings were taken for naked vision. The slide holder of the telebinocular was set at +.50 instead of .00. Using 90 per cent as a passing score, 15.2 per cent were referred on the right eye tests and 20 per cent on the left eye tests. Using 100 per cent as a passing score, 18.4 per cent were referred on the binocular test. Using 90 per cent as a passing score on all three tests, 26.4 per cent of the individuals were referred. Five of the cases not referred made scores of 90 per cent on the binocular test. Including these cases, approximately 30 per cent would have been referred.

TABLE VII

**Summary of Visual Efficiency Data (Betts Tests, DB—1, 2, and 3)**

| % | O.D. | O.S. | O.U. |
|---|---|---|---|
| 110 | 3 | 2 | 6 |
| 105 | 46 | 31 | 59 |
| 100 | 43 | 53 | 37 |
| 90 | 14 | 14 | 13 |
| 80 | 3 | 5 | 4 |
| 70 | 2 | 3 | 0 |
| 60 | 3 | 6 | 5 |
| 50 | 0 | 2 | 1 |
| 40 | 4 | 3 | 0 |
| 30 | 2 | 1 | 0 |
| 20 | 2 | 1 | 0 |
| 0 | 3 | 4 | 0 |
| Total | 125 | 125 | 125 |
| M. | 92.3 | 90.2 | 99.2 |

**Summary**

The relationship between *visual acuity* and other findings taken in this study will be presented in subsequent publications. Similar data will be presented on *minimum visible with binocular fusion.*

1. Approximately twenty-eight per cent of the population would be referred to a specialist on the basis of near and far visual acuity findings. These findings were taken by a competent refractionist. It appears that more effective use of visual acuity charts can be made in schools and in industry.

2. Approximately 26 per cent of population was referred on the basis of the three visual efficiency slides of the Betts Ready to Read Tests.

3. More than 25 per cent of the cases evidenced unequal visual acuity.

4. All but 3.3 per cent of the cases achieved 20/20 or better visual acuity in the right eye through the subjective; 9.1 per cent, in the left eye. 9.9 per cent of the individuals were unable to achieve 20/20 or better vision in one or both eyes through the subjective.

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# Part IV

## Interpupillary Distance

In schools and industry there is very little need for determining the interpupillary distance. Present instruments used for testing require no adjustment for such variations. There is no checking of spectacles or writing of prescriptions.

A previous study by Betts (2, p. 138) indicates the need for a study from a maturation point of view:

"A phase of anatomical maturation meriting further research is the increase with age of the distance between the pupils of the eyes. This interpupillary distance is probably largely controlled by the growth of the head. If any significance can be attached to this factor, it would probably be the sixth and seventh years, the first and second grades of school, when the greatest gain is evidenced. Unless the subject compensates for this change by holding the reading material at a slightly greater distance from him, more convergence (turning in of the eyes) would be required to maintain the same degree of binocular co-ordination."

For this study, interpupillary distance was determined by measuring, with a millimeter rule, the distance between corresponding margins of the two corneas. The subject was instructed to fixate on the examiner's left eye, then on the right eye. This procedure is described by Beach (1, p. 158).

Duane (3, pp. 366-367) describes a procedure for determining the interocular or intercentral distance. He points out that this is 'usually two or three millimeters less than the interpupilary distance.' The visual point, where the line of sight passes through the cornea, "usually lies to the inner side of the center of the pupil." The angle formed between the pupillary line and the visual axis is called angle kappa.

Table I is a summary of the findings on interpupillary distance.

**Table I**
**Distribution of P.D.'s**

| MM. | Boys | Girls | Total |
|---|---|---|---|
| 54 | 0 | 2 | 2 |
| 55 | 1 | 1 | 2 |
| 56 | 5 | 3 | 8 |
| 57 | 4 | 3 | 7 |
| 58 | 5 | 10 | 15 |
| 59 | 12 | 7 | 19 |
| 60 | 9 | 11 | 20 |
| 61 | 6 | 6 | 12 |
| 62 | 11 | 7 | 18 |
| 63 | 3 | 2 | 5 |
| 64 | 4 | 5 | 9 |
| 65 | | 0 | 0 |
| 66 | | 2 | 2 |
| Total | 60 | 59 | 119 |
| M. | 59.90 | 59.88 | 59.89 |
| S.D. | 2.28 | 2.67 | 2.48 |

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# Part V

## Ocular Motility

One of the first steps in either a diagnostic or screening procedure is the determination of the status of basic visual skills. A fundamental principle of teaching is "Begin where the learner is." This applies to the teaching of basic visual skills as well as to the development of basic reading abilities. If an individual does not have normal *monocular* pursuit and fixation ability, then the practitioner is not likely to be successful if he initiates the reconditioning program at the *binocular* level.

A second fundamental principle of teaching is "Instruction should be systematic." In view of this principle, educators and psychologists have concerned themselves with the study of systematic sequences in the development of basic abilities. As a result, greater emphasis has been placed on readiness for learning. Recent studies on the psycho-physiology of seeing have indicated the possibility and desirability of considering the readiness factor in practice. The anatomical (sometimes called "the eye-ball") approach to refraction precluded the adoption of this second basic principle of learning. Those refractionists concerning themselves with the psycho-physiological approach are, of necessity, students of readiness and of systematic sequences in the development of comfortable and efficient patterns of seeing.

### Reconditioning Sequence

In orthoptics, the monocular reconditioning sequence is usually referred to as the *Primary Sequence.* This includes monocular rotations, monocular fixations, and accommodative exercise. The *Secondary Sequence* includes binocular rotations, fusion, binocular fixation, and stereopsis. It appears to be as necessary to develop monocular skills before dealing with binocular skills as it is to teach certain arithmetic processes before giving instruction in algebra. "Stereoscopic vision and depth perception is the goal of all preliminary training and may be considered to be the last stage in the development of binocular vision." (12, p. 1)

Ocular motility is of concern to the modern refractionist for a number of reasons: First, binocular seeing skills must be based on adequate monocular skills. Second, a study of ocular motility provides the refractionist with an index to readiness for the learning of seeing skills at various levels. For example, pathological conditions limiting the development of ocular motility can be identified quickly. There are individuals who may never profit from systematic instruction in reading. Likewise, there are cases who may never profit from orthoptics. An ocular motility test is one kind of a readiness test. Third, ocular motility findings provide one index to the types of concessions made by the individual in the interests of singleness and clearness of vision. Fourth, the orthoptist is provided with one means for measuring progress in the development of adequate visual skills. "Everyone intending to follow the tried and proven procedure.....should begin immediately to take these various tests as they constitute the first step in the practice of orthoptics." (13, p. 1)

Duane concluded (3, pp. 210-211): "It is essential in testing the refraction that the *motility* be examined at the same time. Sometimes symptoms, apparently due to refractive errors are really due to motor anomalies, and, moreover, the presence of the latter may have some bearing on the question of the glass to be prescribed."

Dr. Luther Peter (14, p. 98) makes these remarks regarding studies of arc rotations: "These studies are of greater importance in squint. In all complicated cases of heterophoria, however, the rotating power of each eye may be of much help in arriving at the best method of treatment of the heterophoria."

Students of the psycho-physiological approach are concerned with the study of ocular motility. They have substituted psychological, physiological, and neurological concepts of seeing for anatomical concepts. They do not permit their thinking to be circumscribed by fallacious statements regarding "strong and weak" muscles, "length of the eye ball," and "eye strain." They are as much concerned about what is happening behind the retina as they are about the structure and pathology of the eye ball. In short, the psycho-physiology of seeing merits consideration.

If the extrinsics are strong enough to move the eyes during the ocular motility tests, then there are no "weak" muscles. In fact, very little "power" is required to move an eye.

This point of view expressed by Skeffington and by Lancaster is summarized by Halgren (7, p. 1.): ".....we find that the muscles of the eyes vary in different individuals as to length, width, attachment, etc., just as everything else in the human body varies. Yet, if any person can move his eyes to the limitations of the orbits there can be nothing wrong with muscles controlling the movements of his eyes. Also, if a person can focus his eyes at different distances there cannot be anything wrong with the muscles controlling the crystalline lens."

### Analysis Techniques

The ocular motility findings are taken in the reading clinic by means of a special fountain pen flashlight. (See article on near point of convergence for types of test targets in common use.) Monocular rotations and versions are checked before binocular findings are taken.

The following are the steps used in taking ocular motility findings:

1. *Monocular Rotations and Versions.*

The right eye is occluded and the subject is requested to look at (to fixate) the target held about twenty-four inches from the eye. If a light is used, the reflected image of it will be seen in the center of the cornea at all times. When the individual cannot follow the target, the image will be observed to move from the center of the cornea. The target is moved temporal-wise first, then in a circle within the full limits of the individual's ability to follow. Duane (3, p. 299) reports: "In moving outward the edge of the cornea should reach the outer and in moving inward should reach the inner canthus." By tipping the occluding card nasal-ward, the operator can observe the behavior of the eye under occlusion. Most operators do not move the target slowly enough to detect significant irregularities. Rotations are taken first with clockwise motion; then with counter-clockwise motion.

In addition to pursuit movements, versions are studied. The target is moved slowly from the primary position in the diagnostic directions: Vertical, horizontal, and oblique. Observations are made of the ability to maintain fixation and smoothness of fixation. Some individuals tend to "over-shoot" as the target is moved slowly from the primary position to the extreme limit of the fixation field. These regressive movements are noted. Following this, the left eye is occluded and the movements of the right eye are checked.

2. *Binocular Rotations and Versions.*

The examiner takes the binocular findings in the same manner as the monocular findings.

3. *Near and Far Fixations.*

The subject is instructed to read the smallest letters on a distance Snellen chart or some other suitable target, then immediately to fix on a target held twelve to fourteen inches from the eyes. A number of trials are given with the subject fixing alternately on the distance and the near targets. These near and far fixations should be achieved (a) smoothly, i. e., without "fumbling" movement, and (b) quickly. Faulty fixation is usually revealed by sluggish movement, lack of rhythm, and corrective (or regressive) movements.

### Recording the Findings

A special form is used in the reading clinic for recording data on rotations and versions. Two pairs of circles, each with four principal meridians, are arranged on the record form so that rotation and version findings at both monocular and binocular levels may be recorded. One circle is used for each eye. Faulty rotations in given meridians are indicated with an irregular (wavy) line. Restricted versions are indicated by a short line drawn at right angles to the meridian in which the restriction is observed. The findings are summarized as N (normal), F (fairly smooth), and S (saccadic) rotations and as "faulty" or "accurate" fixations. A notation is also made of head movement.

The chief general information to be secured is, "Can the individual move each eye smoothly and accurately within the field of fixation?" This should be achieved without head movement. Specifically the following observations should be made: First, is there a sluggish neuro-muscular response? Second, is there a normal distribution of innervation to the extrinsics? Third, is the field of excursion limited in any way? If so, is the limitation structural, paralytic, or a functional concession? Fourth, does the macular area present an over-all responsiveness as indicated by smooth and accurate fixation? Individuals with adequate ocular motility can follow smoothly and accurately a target moved within the field of direct vision.

### Cranial Nerves and the Extrinsics

The following chart is a summary of information on cranial, or cerebral, nerves, and the extrinsic muscles. This information is valuable largely for detecting paresis. The writers are confining their attention mostly to interferences in the binocular functions of individuals who do not exhibit struc-

## CRANIAL NERVES AND EXTRINSIC MUSCLES

| Nerve | Supplies | Primary action | Subsidiary action |
|---|---|---|---|
| Third: Oculomotor | a. Superior rectus (Superduction) | Elevation | Intorsion<br>Internal rotation |
| | b. Inferior reetus (Subduction) | Depression | Extorsion<br>Internal rotation |
| | c. Internal or medial rectus (Adduction) | Internal rotation | None |
| | d. Inferior oblique | Extorsion | Elevation<br>External rotation |
| | e. (Also sphincter muscle of the iris and ciliary) | | |
| | f. (Also levator palpebrae) | | |
| Fourth: Trochlear or pathethicus | a. Superior oblique | Intorsion | Depression<br>External rotation |
| Sixth: Abducens | a. External or lateral rectus (Abduction) | External rotation | None |

tural or pathological defects in the seeing mechanism.

### Data on Ocular Motility

11.6 per cent of the cases evidenced faulty motility. Of the fourteen cases with faulty motility, five, or 35.5 per cent, had 20/20 or better visual acuity. The data on ocular motility are summarized in Table I.

**Table I**

**Summary of Findings on Ocular Motility**

| Condition | f | % |
|---|---|---|
| Normal | 107 | 88.4 |
| Faulty rotations | 2 | 1.7 |
| Faulty versions | 3 | 2.5 |
| Faulty rotations and versions | 8 | 6.6 |
| Exaggerated head movements | 1 | 0.8 |
| Total | 121 | 100.0 |

One case was described with "exaggerated head movements." V.A. was 20/200 in each eye and the N.P.C. was 4.5 cm.

Two cases were referred because of faulty rotations. Case No. 27 had 20/15 V.A. in each eye; case No. 12, 20/25. Both cases had 14/14 V.A. in each eye. Case No. 27 had an N.P.C. of 5 cm.; case No. 12, 12 cm. On the basis of criteria to be described later, both cases required near-point correction.

Three cases were referred because of faulty versions: Case No. 32 had 20/15 (O.D.) and 20/70 (O.S.), and an N.P.C. of 2.5 cm. Case No. 56 had 20/20 V.A. in each eye and an N.P.C. of 5 cm. Case No. 97 had 20/20 V.A. in each eye and an N.P.C. of 20 cm. Cases No. 56 and 97 presented findings which meet criteria established to determine need for orthoptics. In short, all three of these cases were in need of referral to a specialist.

**Table II**

| | V.A. (Naked) | | | |
|---|---|---|---|---|
| Case | O.D. | O.S. | N.P.C. | Treatment |
| 3 | 20/20 | 20/400 | 9.0 | Glasses |
| 19 | 20/15 | 20/15 | 2.5 | None |
| 62 | 20/60 | 20/60 | 1.5 | Glasses |
| 70 | 20/15 | 20/15 | 3.0 | None |
| 85 | 20/20 | 20/400 | 7.0 | Glasses |
| 91 | 20/100 | 20/15 | 5.0 | Glasses |
| 93 | 20/30 | 20/50 | 4.5 | Glasses |
| 120 | 20/200 | 20/15 | 2.0 | Glasses |

Eight cases exhibited both faulty rotations and versions. Three-fourths of these cases were in need of referral. These data are summarized in Table II.

### Summary

1. Approximately 10 per cent of the cases evidenced faulty ocular motility.
2. There does not appear to be a high relationship between ocular motility and visual acuity or near point of convergence.
3. The problems presented by these cases were of a psycho-physiological nature. No paresis was detected.
4. Ocular motility findings are valuable for both diagnostic and screening purposes.

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# Part VI

## Symptoms

This report deals largely with symptoms of ocular discomfort or a lack of clearness of vision. As will be demonstrated, symptoms have value for screening as well as for diagnostic purposes. If the teacher or school nurse will use some systematic means for identifying pupils with ocular discomfort or seeing inefficiency, a substantial percentage of the school population can be referred to a specialist. It is unfortunate, however, that society waits for the horse to be stolen before locking the barn. Certainly, more attention should be given to prevention than to correction.

The symptoms considered in this phase of the study are those reported by the subjects. A thorough symptoms inventory should provide information on photophobia, asthenopia, vertigo, headaches, ocular aches and pains, itching, drowsiness from sustained seeing activities, indistinct vision, and the like. In addition, observations should be made regarding head tilting, excessive blinking, excessive head movement in reading activities, squinting, widely dilated pupils, inflamation, and kindred items.

Because of a lack of inter-professional understanding regarding seeing problems, the teacher or school nurse is not always in a position to refer children in need of a specialist's attention. As a result, pupils continue to engage in strenuous seeing activities without proper attention to their visual problems. Not only are they laboring under handicaps so far as the school (or industrial) situation is concerned but also they may be victims of the cumulative effects of the handicap. Health as well as educational achievement may be jeopardized.

This lack of inter-professional understanding is being cleared away rapidly. Through the continued scientific study of seeing problems, the specialist is becoming better prepared to understand the *near-point* problems of *binocular* seeing. Until there is this understanding, the specialist is not in a position to cooperate with schools and industry. Not only must the specialist be prepared to deal with these problems but also he must be prepared to educate parents, teachers, and personnel directors. It is unfortunate, indeed, that this pressure to study the functional aspects of the problem has been coming from non-specialists in seeing.

The teacher and the school nurse have been placed in the professionally awkward position of referring cases to specialists who lacked a basic understanding of the problems. These non-specialists in seeing usually lack the background to defend their action. Certain specialists unconsciously have resorted to undesirable psychological mechanisms in order to maintain their self-respect. It is not uncommon for even a specialist to take only visual acuity findings, to completely overlook symptoms and other crucial findings, and to make a sarcastic report to the parents. This type of "service" does not build for inter-professional cooperation. But far more important, the child is left without attention to his seeing needs.

In the near future, most specialists in seeing will come to welcome every referral from industry or from public schools. Before this can happen, however, they must accept the proposition that prevention of seeing difficulties is their chief obligation. It is difficult to see how each individual specialist can participate in a program of prevention until he makes a psycho-physiological approach to refraction.

At the present time, one of the chief dangers of referring "questionable" cases to practitioners is the "specs fitter." Until refractionists prepare themselves to do more than prescribe glasses on a "short or long eye-ball" or a "weak and strong muscle" basis, they are likely to prescribe glasses where they are unnecessary or to miss other important factors in their analysis of visual needs.

Certainly it is true that many non-specialists in seeing are guilty of trying to tell the refractionist what should be done about individual cases.

Inter-professional cooperation is likely to be furthered to the degree that teachers and nurses have an understanding of seeing problems.

**Results of School Survey Inventory of Symptoms**

A symptoms inventory was developed for use in this study. This was administered to each of the four classes in much the same manner as a *group* test is administered. No data were secured on the reliability of this form and this procedure, but it would be reasonable to expect a lower reliability when used as a group inventory than when used as an individual inventory.

Data from the symptoms inventory were secured on 126 cases. More than data on symptoms were made available on this form. The following is a summary of these data. The number of cases responding to each question is recorded in parentheses after the item.

**Chart I**

**Inventory of Symptoms: Vision**

| | | | |
|---|---|---|---|
| 1. | Do you like to read stories? | (126) | Yes 98.4% (124); No 1.6% (2). |
| 2. | Do you like to study? | (126) | Yes 90.5% (114); No 9.5% (12). |
| 3. | Do you wear glasses now? | (126) | Yes 14.3% (18); Never 81.7% (103); Previously 4.0% (5). |
| 4. | If you are wearing glasses now, how many years have you worn them? | (17) | Less than 1 yr. 11.8% (2); 1 yr. 29.4% (5); 2 yrs. 35.3% (6); 3 yrs. 11.8% (2); 4 yrs. 5.9% (1); 6 yrs. 5.9% (1). |
| 5. | When was the last time you had your eyes examined in a doctor's office? | (126) | Never 74.6% (94); Less than 1 yr. 8.7% (11); 1 yr. 8.7% (11); 2 yrs. 5.6% (7); 3 yrs. 2.4% (3). |
| 6. | When was the last time you had your lenses changed? | (17) | Within a year 35.4% (6); 1 yr. 5.8% (1); 2 yrs. 11.6% (2); never 46.4% (8). |
| 7. | Can you see easily what the teacher has written on the blackboard? | (126) | Yes 94.4% (119); No 3.2% (4); Sometimes 2.4% (3). |
| 8. | Can you read the print in your school books easily? | (123) | Yes 96.7% (119); No 2.4% (3); Sometimes .9% (1). |
| 9. | Can you read the print in the telephone book easily? | (114) | Yes 91.2% (104); No 8.8% (10). |
| 10. | Does print ever blur (become dim or fuzzy)? | (124) | Yes 27.4% (34); No 56.5% (70); Sometimes 16.1% (20). |
| 11a. | Do you ever see double (such as two lines of print) when you are reading? | (126) | Yes 19.0% (24); No 71.4% (90); Sometimes 9.5% (12). |
| 11b. | Do you ever see two people or two cars when you are looking far away when you know there is only one? | (125) | Yes 8.0% (10); No 89.6% (112); Sometimes 2.4% (3). |
| 12. | Do your eyes tire when you read? | (125) | Yes 35.2% (44); No 44.8% (56); Sometimes 20.0% (25). |
| 13. | Do you shade your eyes when you read? | (126) | Yes 6.4% (8); No 81.7% (103); Sometimes 11.9% (15). |
| 14. | Do you ever cover one eye with your hand or a card when you read? | (125) | Yes 24.8% (31); No 73.6% (92); Sometimes 1.6% (2). |
| 15a. | Do bright lights hurt your eyes? | (125) | Yes 40.8% (51); No 41.6% (52); Sometimes 17.6% (22). |
| 15b. | Does sunlight hurt your eyes? | (126) | Yes 38.1% (48); No 45.2% (57); Sometimes 16.7% (21). |
| 16a. | Do you have headaches? | (126) | Yes 41.3% (52); No 32.5% (41); Sometimes 26.2% (33). |
| 16b. | After a movie? | (76) | Yes 34.2% (26); No 46.0% (35); Sometimes 19.7% (15). |
| 16c. | After reading? | (90) | Yes 10.0% (9); No 71.1% (64); Sometimes 18.9% (17). |
| 17. | Do you ever become nauseated (sick at your stomach)? | (123) | Yes 55.3% (68); No 14.6% (18); Sometimes 30.1% (37). |
| 18. | Do you ever get car-sick? | (125) | Yes 28.8% (36); No 57.6% (72); Sometimes 13.6% (17). |
| 19a. | Do your eyes itch? | (122) | Yes 20.5% (25); No. 66.4% (81); Sometimes 13.1% (16). |
| 19b. | Do your eyes burn? | (119) | Yes 16.8% (20); No 68.1% (81); Sometimes 15.1% (18). |
| 19c. | Do your eyes ever tear (water)? | (122) | Yes 39.3% (48); No 42.6% (52); Sometimes 18.0% (22). |
| 20. | Do your eyes get inflamed? | (121) | Yes 19.0% (23); No 71.1% (86); Sometimes 9.9% (12). |
| 21. | Do you ever have styes? | (121) | Yes 16.5% (20); No 77.7% (94); Sometimes 5.8% (7). |
| 22. | Do you ever get dizzy? | (124) | Yes 46.0% (57); No 51.6% (64); Sometimes 2.4% (3). |
| 23. | Do you ever see spots before your eyes? | (121) | Yes 13.2% (16); No 81.0% (98); Sometimes 5.8% (7). |
| 24a. | Do you ever feel nervous? | (124) | Yes 38.7% (48); No 46.0% (57); Sometimes 15.3% (19). |
| 24b. | Do you bite your fingernails? | (124) | Yes 41.1% (51); No 45.2% (56); Sometimes 13.7% (17). |
| 24c. | Do your eyes twitch? | (124) | Yes 13.7% (17); No 79.8% (99); Sometimes 6.5% (8). |
| 24d. | Do your eyelids twitch? | (121) | Yes 13.2% (16); No 84.3% (102); Sometimes 2.5% (3). |
| 24e. | Does your nose twitch? | (122) | Yes 2.5% (3); No 96.7% (118); Sometimes .8% (1). |
| 24f. | Do your lips twitch? | (122) | Yes 3.3% (4); No 96.7% (118). |
| 24g. | Does the side of your face twitch? | (118) | Yes .8% (1); No 97.5% (115); Sometimes 1.7% (2). |

The data from the symptoms inventory are summarized in Table I.

**Table I**

**Summary of Symptoms Inventory**

| | f | % |
|---|---|---|
| 1. Ocular discomfort (only) | 26 | 21 |
| 2. Lack of clearness of seeing (only) | 15 | 12 |
| 3. Combination of 1 and 2 | 27 | 21 |
| 4. No reported difficulties | 58 | 46 |
| Total | 126 | 100 |

### Symptoms Reported to the Refractionist

Approximately 57 per cent reported no symptoms of ocular discomfort or visual inefficiency. The chief complaints were headaches, eye aches, blurred vision, tearing, and burning. These accounted for approximately 70 per cent of the complaints. These data are summarized in Table II.

### Summary

The relationship between symptoms and visual analysis findings taken in this study will be presented in subsequent publications. One criterion used for referral and for correction was the general response to the symptoms inventory.

1. A substantial percentage of the school population can be referred on the basis of reported symptoms.

2. Symptoms should be studied for near point seeing situations as well as for distance seeing situations.

**Table II**

**Summary of Reported Symptoms**

| | | f | % |
|---|---|---|---|
| No ocular discomfort or seeing difficulty | | 70 | 57.4 |
| Headaches only | | 9 | 7.4 |
| After close application | 3 | | |
| After movies | 3 | | |
| No specific time | 3 | | |
| Eye ache only | | 6 | 4.9 |
| After reading | 3 | | |
| After movies | 1 | | |
| After reading and movies | 2 | | |
| Blurred vision only | | 9 | 7.4 |
| At near | 5 | | |
| At distance | 4 | | |
| Tearing only | | 8 | 6.6 |
| Burning only | | 5 | 4.1 |
| Spots before eyes and burning | | 1 | 0.8 |
| Spots before eyes and headaches | | 1 | 0.8 |
| Headache and tearing | | 3 | 2.5 |
| Headache and blurring | | 4 | 3.3 |
| Headache and burning | | 1 | 0.8 |
| Eye ache and blurring | | 1 | 0.8 |
| Eye ache and tearing | | 1 | 0.8 |
| Tearing and blurring | | 1 | 0.8 |
| Tearing and burning | | 1 | 0.8 |
| Tearing, burning, blurring and diplopia | | 1 | 0.8 |
| Total | | 122 | 100.0 |

### References


1. Betts, Emmett A. *Prevention and Correction of Reading Difficulties.* Evanston, Illinois: Row, Peterson and Company, 1936.
2. Betts, Emmett A. "Seeing and Reading." *Visual Digest,* Vol. III, No. 3, December, 1939, January-February, 1940, pp. 37-45.

# Part VII

## Pathology

Adequate attention to the seeing problems of school children requires an ocular examination as well as a visual analysis. The ocular examination is limited largely to the detection of external and intra-ocular pathology. Non-medical practitioners, nurses, and teachers can easily detect external pathological conditions. A licensed practitioner should be able to detect intra-ocular pathology. Since there appears to be a fairly high relationship between external pathology and interferences in the binocular functions, the ocular conditions found should be interpreted in terms of the visual analysis findings.

Duke-Elder summarizes the (day light) examination for detecting external pathology (4, p. 218):

> "The state of the lids and conjunctivae should be examined, and the occurrence of blepharitis, styes, and conjunctivitis should be noted, and the ocular congestion which may denote refractory errors discriminated from the injection of inflammatory disease. The lacrimal puncta and sacs should receive attention, especialy where weeping is one of the symptoms, giving rise to complaint. The cornea should be examined, its transparency verified, keratitic deposits looked for, and the nature of its reflex investigated. The depth of the anterior chamber should be assessed, and the clear nature of its contents verified; the appearance of the iris, the shape and reactions of the pupils, and the presence of synechiae should be noted; and in all cases an estimate should be made of the intra-ocular tension. A rough test should be made of the mobility of the eyes, and the presence or absence of squint excluded. Thereafter a rapid estimate should be made of the extent of the visual field."

The following suggestions are made by Duke-Elder regarding the detection (dark-room) of intra-ocular pathology (4, pp. 218-219): "A preliminary examination of the interior of the eye should then be undertaken with the plane mirror, and any opacities in the media looked for and located while the eye is moved in various directions. At the same time the nature of the retinal reflex should be studied, and any inequalities in its appearance such as are indicative of retinal detachment looked for. The fundus should then be examined throughout its entire extent with the opthalmoscope, particular attention being paid to the condition of the macula and optic disc and the state of the vascular system."

A summary of external pathology is presented in Chart I. Only the more common diseases are charted. Such diseases as vernal conjunctivitis (spring catarrh) and the like are infrequently found. Although they may be crucial, their *frequency* of occurrence does not merit consideration here. It will be noted that the "symptoms" given do not refer to the sub-types of a given pathological finding. This also holds for the "possible causes."

The writers are indebted especially to Doctor William T. Hunt, Jr., for his constructive criticism of the chart used in this report. They also appreciate the help of Doctor Carl F. Shepard, Chief of Staff, THE OPTOMETRIC WEEKLY.

## CHART I
### External Pathology

| PATHOLOGY | AREA | SYMPTOMS | TYPES | POSSIBLE CAUSES |
|---|---|---|---|---|
| I. Blepharitis<br>(Blepharitis ciliaris or Blepharitis marginalis) | Eyelid margin<br>(Acute or chronic inflammation of the skin and glands of the lid margins) | 1. Reddening and thickening of margins of lids<br>2. Sometimes associated with scales and crusts<br>3. Loss of cilia (eyelashes) | 1. Ulcerative (blepharitis ulcerosa)<br>2. Non-ulcerative (blepharitis squamosa) | 1. Interference in the binocular functions<br>2. Infections<br>3. Allergies<br>4. Mechanical irritation, such as rubbing the eyes |
| II. Conjunctivitis (ophthalmia)<br>A. Catarrhal<br>(Conjunctivitis catarrhalis) | | | | |
| | 1. Bulbar and palpebral conjunctiva and fornix | 1. Tearing<br>2. Itching and smarting<br>3. Inflammation<br>4. Area brilliant red with oedema<br>5. Photophobia, etc. | 1. Acute<br>(Acute epidemic conjunctivitis is popularly known as "pink eye." Swimming-pool conjunctivitis usually occurs in mild epidemics.) | 1. Mechanical irritation<br>2. Epidemic<br>3. Infections<br>4. Exanthema, etc. |
| | 2. Bulbar and palpebral conjunctiva | Milder in degree than for acute, except palpebral conjunctiva reddened, smooth, and velvety | 2. Chronic (chronic simple conjunctivitis) | 1. Sequelea of acute catarrh<br>2. Insufficient rest<br>3. Lowered vitality<br>4. Vitiated atmosphere<br>5. Interference in the binocular functions, etc. |
| | 3. Mostly palpebral conjunctiva of the lower lid | Small white or translucent bodies (granulations or follicles) in the lower retrotarsal fold | 3. Follicular | 1. Poor hygienic surroundings<br>2. Anemia<br>3. Prolonged use of atropine, or eserine, etc. |
| B. Purulent<br>(Conjunctivitis gonorrhoica) | Palpebral and retrotarsal conjunctiva of both eyes | | | |
| | | 1. Purulent discharge<br>2. Also 2 and 3 below | 1. Infantile: ophthalmia neonatorum | Gonococcus from vagina of mother |
| | | 1. Purulent discharge<br>2. Swelling, redness, tenseness of lids<br>3. Usually begins monocularly<br>4. Constitutional disturbances, such as temperature and swelling of preauricular glands | 2. Adult: gonorrheal ophthalmia | Gonococcus |
| C. Membranous | Palpebral conjunctiva | | | |
| | | 1. Swollen, reddened, hard, and painful lids<br>2. Grayish yellow exudation which penetrates the palpebral conjunctiva<br>3. Constitutional symptoms of diphtheria | 1. Diphtheritic | 1. Virulent diphtheria bacillus (Klebs-Loeffler)<br>2. Streptococcus brevis |
| | | 1. Less severe than diphtheritic<br>2. Exudation does not invade the conjunctiva | 2. Non-diphtheritic or croupous | 1. Bacterial<br>2. Mechanical<br>3. Chemical |
| D. Granular or trachoma<br>(Conjunctivitis trachomatosa) | Palpebral conjunctiva | | | 1. Contagion<br>2. Causative organism not isolated |
| | | 1. Small elevations (papillae)<br>2. Thickened conjunctiva<br>3. Red, velvety appearance<br>4. Photophobia<br>5. Tearing, itching, burning<br>6. Feeling of a foreign body<br>7. Pain<br>8. Visual disturbances<br>9. Swelling of lids<br>10. Narrowing of palpebral aperture<br>11. Drooping of upper lid<br>12. Muco-purulent discharge | 1. Papillary | |
| | | 1. Gray, rounded translucent bodies showing through the palpebral conjunctivae<br>2. See items 4 to 10 above | 2. Granular<br>3. Mixed | |

| | | | | |
|---|---|---|---|---|
| E. Phlyctenular (Eczematous conjunctivitis or scrofulous ophthalmia) | Limbus of conjunctiva | 1. Phyctenules, or circumscribed projections<br>2. Blepharospasm<br>3. Marked tearing<br>4. Photophobia | 1. Simple | 1. Malnutrition<br>2. Avitaminosis<br>3. Unhygienic surroundings, etc.<br>4. Tuberculous |
| | | | 2. Multiple | |
| III. Corneal opacity | Cornea | 1. Cloudiness<br>2. Loss of lustre<br>3. Sometimes elevation of surface | 1. Corneal nebula (translucent and faint)<br>2. Corneal macula<br>3. Corneal leucoma (dense) | 1. Injury<br>2. Infection |
| IV. Lid tumors. | Eye lids | | 1. Benign | |
| | | Flat or slightly raised yellowish discoloration | a. Xanthelasma | Fatty degeneration of connective tissue cells |
| | | Small white rounded tumor | b. Molluscum | Diseased condition of sebaceous glands |
| | | | c. Verruca (wart) | |
| | | Transparent contents | d. Cyst (vesicles) | Obstruction of sweat glands |
| | | Small yellowish white elevation, size of pin head | e. Milium | Retention of sebaceous material |
| | | | 2. Malignant | |
| | | Small pimple or wart covered with a crust; becomes an ulcer | a. Carcinoma | |
| | | | b. Sarcoma (rare) | |
| V. Hordeolum or stye | Glands of Zeis, Moll, or the Meibomian glands | Inflammation at the edge of lid | 1. Hordeolum externum (Zeisianum)<br>2. Hordeolum internum (Meibomianum) | 1. Interference in binocular functions<br>2. Lowered vitality<br>3. Associated with blepharitis |
| VI. Chalazion | Enlargement of one of the Meibomian glands | Hard swelling | | Occlusion of the duct |
| VII. Trichiasis | Inversion of lashes | 1. Mechanical irritation of eyeball<br>2. Tearing<br>3. Photophobia | | 1. Cicatricial contraction of conjunctiva and/or tarsus<br>2. Associated with entropion |
| VIII. Entropion | Rolling in of lid border | 1. Pain<br>2. Photophobia<br>3. Feeling of a foreign body<br>4. Irritation of the cornea | 1. Cicatricial | Contraction of the conjunctiva |
| | | | 2. Spastic | Contraction of the fibers of the palpebral portion of the orbicularis muscle |
| IX. Ectropion | Eversion of the eyelid | 1. Tearing<br>2. Reddening of conjunctiva<br>3. Eversion of the lid | 1. Cicatricial<br>2. Spastic<br>3. Senile | Contraction of skin and tarsus<br>Blepharospasm<br>1. Senile relaxation of the fibers of orbicularis muscle<br>2. Chronic catarrh |
| | | | 4. Paralytic | Paralysis of orbicularis |
| X. Oedema of lids | Eyelids and surrounding tissue | Recurrent swelling which appears quickly; no pain | 1. Inflammatory | 1. Accompanying styes, chalazia and other lid affections and nasal infections, etc. |
| | | | 2. Traumatic | 2. Injuries, insect stings |
| | | | 3. Systemic | 3. In renal and cardiac diseases |
| | | | 4. Non-inflammatory | 4. In women (mostly) and with urticaria |
| XI. Ptosis | Upper lid | Drooping of upper lid—all degrees | 1. Congenital | 1. Improper development of levator muscle |
| | | | 2. Acquired | 2. Paralysis of the branch of third nerve supplying the levator |
| XII. Dacryocystitis | Lacrymal sac and duct | Tearing<br>Fullness of lacrymal sac; when pressed, expels viscid fluid | 1. Chronic | 1. Obstruction of nasal duct due to swelling from nasal infection |
| | | | 2. Acute | 2. Probing in attempt to correct chronic condition. |

### Findings

25.6 per cent of the population showed evidence of pathology which would refer them for an eye examination. Only 1.6 per cent of the cases were found to have intra-ocular pathology requiring the attention of a specialist. In neither of these two cases was the prognosis encouraging. No additional intra-ocular pathology was detected after the use of a cycloplegic. Any of the external pathology found could have been detected by a well-prepared nurse or teacher.

The data on pathological findings are summarized in Table I.

**Table I**
**Summary of Pathological Findings**

| | f | % |
|---|---|---|
| Blepharitis | 11 | 9.1 |
| Conjunctivitis | 8 | 6.6 |
| Blepharitis and Conjunctivitis | 7 | 5.8 |
| Ptosis | 1 | 0.8 |
| Tropia | | |
| Exo | 1 | 0.8 |
| Eso | 1 | 0.8 |
| Disseminated Choroiditis | 1 | 0.8 |
| Corneal opacity | 1 | 0.8 |
| Normal | 90 | 74.4 |
| Total | 121 | 100.0 |

### Summary

1. Including corneal opacities, less than two per cent of the cases evidenced intra-ocular pathology.
2. Less than two per cent of the cases exhibited tropias.
3. Blepharitis was the most common pathological finding.

### References


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6. May, Charles H. (M.D.). *Manual of the Diseases of the Eye.* Baltimore: William Wood and Company, 1934.

# Part VIII

## Stereopsis

In 1928, Dr. David W. Wells prophesied (11, p. 14): "When the facts are known, it is quite possible that visual tests will not stop with measuring the acuity of each eye and testing the color sense, but that a certain standard of steropsis will be required."

He continued (11, p. 15):

"Fusion faculty is also a matter of degree. Some patients are able to fuse concrete pictures by a rapid alternation of the two eyes, but have no conception of perspective. Other cases are able to fuse large concrete pictures and have some perspective. Simultaneous macular perception is essential to true binocular fusion."

In discussing the development of stereopsis, Skeffington and his associates comment (8, p. 2): "Stereopsis is not a separate step in orthoptics, but must be considered from the moment that any binocular work is attempted since it is in reality a special form of binocular vision."

Southall summarizes his discussion of the nature of binocular depth-perception as follows (10, pp. 231-33):

"In binocular vision each eye by itself affords a perspective view of the visible objects in front of us, only as the two eyes are separated by an interval of about 2.5 inches on the average from centre to centre, the two images of the same object as seen from these somewhat different standpoints are not exactly alike; and so when they are fused by the brain into a complete visual impression, it is possible to obtain a spatial concept, involving not just simply two dimensions as is usual in monocular vision, but a more or less distinct perception of depth as well as breadth and height, that is, a plastic psychological image of three dimensions. This characteristic binocular depth-perception is what is meant by stereoscopic vision —the kind of vision that enables us to see around an object and to discern, for example, that the face of a coin or medal is not just a flat surface with a pattern stamped on it, as indeed it appears to be when it is held at a considerable distance from the eyes, but that the effigy stands out in more or less bold relief according to the artist's design. The farther off the object is, the less unlike the images will be in the two eyes. Accordingly, the accuracy of binocular judgment of depth diminishes with increase of distance until beyond a certain point which is the limit of stereoscopic vision no difference between the two images can any longer be distinguished at all. Strictly speaking, in order for the images to be absolutely similar in the minutest details the object would have to be infinitely remote, but in a practical sense the radius of steroscopic vision of the naked eye is quite limited and as a rule does not extend much more than about a quarter of a mile depending essentially on the inter-pupillary distance between the two eyes or between their centres of rotation . . ., which according to age, race, etc., varies among human beings from 50 to 74 mm., the average value for Caucasian adults being perhaps around 62 mm."

Dr. Luther C. Peter makes the following comments regarding the evolution of binocular vision (9 pp. 78-79):

"A study of the evolution of binocular vision is of much interest. In the lowest orders of animal life the eyes are placed in the sides of the head. There is no overlapping of the visual fields. The eyes operate independently. In ascending the scale of the animal kingdom the eyes gradually move forward and the visual fields begin to overlap. There now is a tendency to concerted action. In

the higher orders the visual axes tend to approach parallelism. Only in apes and in man, however, does parallelism reach a reality. With parellelism of the axes, binocular vision not only becomes possible, but essential."

Tests of stereopsis have proved to be valuable for a number of purposes: First, they are serviceable in screening out cases in schools and industry that evidence interferences in the binocular functions. Second, the refractionists are provided with another technique for appraising achievement in regard to the seeing processes. Third, orthoptists are given a means for measuring the progress of the patient. Still more important, the patient can be made aware of progress. Demonstration of progress is a potent factor in any learning situation. Fourth, stereoscopic tests have intrigued laymen and have done much to interest the general public in binocular vision. Much has yet to be learned regarding the development, use, and interpretation of tests of stereopsis.

### Referral (2)

The Visual Sensation and Perception Tests of the Betts Ready to Read Battery were designed for the purpose of *detecting*, or *screening out*, those individuals who should be referred to a specialist for diagnosis. Until more adequate provision is made in the schools, it is the obligation of the school doctor, nurse, or teacher to detect cases in need of a specialist's attention. When an individual has been referred, the problem should rest in the hands of the specialist. Occasionally, the specialist may have recommendations for the teacher to follow.

As pointed out by Duke-Elder, an individual may fail a stereopsis test for a number of reasons. In this case faulty stereopsis or lack of it may be a symptom of one or more underlying difficulties. In the first place, healthy maculae are prerequisites to binocular vision. Secondly, the ocular muscles must function normally. Third, the nervous system must be efficient.

### Instrumentation (2)

Various types of instruments have been devised for determining the presence or absence of varying grades, or levels, of fusion. Probably the most common is some form of a stereoscope. The Worth Amblyoscope is used by many specialists for this purpose.

The study of binocular functions has been facilitated by the development of stereoscopes. The reflecting type of stereoscope devised by Wheatstone has not come into common usage. Most of the present day stereoscopes are based on the refracting type invented by Sir David Brewster.

In discussing means of testing single binocular vision and of detecting malingering, Dr. Luther C. Peter (9, p. 870) comments:

"This latter phase of binocular vision is best studied with the stereoscope. Further, the stereoscope at the same time establishes the fact that the patient has binocular vision. It is the ideal test and does not entail the purchase of additional instruments which can add nothing to the information which the stereoscope can give."

### Findings

Data on the stereopsis slides used in this study have been reported by Betts[2]. The data on the cases used in this study were summarized in that report.

Three hundred fifty readings were recorded on one hundred twenty-three unselected cases in grade five of the Huntingdon, Pennsylvania, Public Schools. Slides DB-6 (for far point) and DB-6A (for near point) were used. The findings were taken by Dr. Agnes S. Austin and Bonnalee Brown of The Reading Clinic, The Pennsylvania State College.

The DB-6 findings were taken with the Telebinocular slide holder set at the equivalent of plus .50, the DB-6A, at the equivalent of plus 2.50. It should be noted that the far-point findings were taken with the slide holder set at the equivalent of plus .50 rather than the equivalent of .00 as recommended in the 1936 manual.

Table I is a summary of all the data on stereopsis for this group of elementary school children. Distributions are presented in terms of both frequency and per cent. It will be noted that only a fraction of the cases were rechecked to determine reliability of the test situation.

**Table I**
**Summary of Data on Stereopsis**
**Fifth Grade Pupils**
**Huntingdon, Pennsylvania**

| Per cent Stereopsis | Far Point (.50) First f. | Far Point (.50) First % | Far Point (.50) Second f. | Far Point (.50) Second % | Near Point (16") First f. | Near Point (16") First % | Near Point (16") Second f. | Near Point (16") Second % |
|---|---|---|---|---|---|---|---|---|
| 100 ... | 101 | 82.11 | 41 | 75.93 | 83 | 67.48 | 35 | 70.00 |
| 90 ... | 9 | 7.32 | 2 | 3.70 | 26 | 21.14 | 7 | 14.00 |
| 80 ... | 0 | 0.00 | 1 | 1.85 | 4 | 3.25 | 3 | 6.00 |
| 70 ... | 3 | 2.44 | 3 | 5.56 | 1 | 0.81 | 0 | 0.00 |
| 60 ... | 3 | 2.44 | 0 | 0.00 | 1 | 0.81 | 0 | 0.00 |
| 50 ... | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| 40 ... | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| 30 ... | 1 | 0.81 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| 20 ... | 1 | 0.81 | 1 | 1.85 | 0 | 0.00 | 0 | 0.00 |
| 10 ... | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| 0 ... | 5 | 4.07 | 6 | 11.11 | 8 | 6.51 | 5 | 10.00 |
| Total | 123 | 100.00 | 54 | 100.00 | 123 | 100.00 | 50 | 100.00 |
| M. ..... | | 101.20 | | 100.00 | | 101.40 | | 101.60 |
| S.D. ..... | | 12.37 | | 12.88 | | 6.78 | | 4.69 |
| Pass 100%.. | | 82.11 | | 75.93 | | 67.48 | | 70.00 |
| Refer Basis.. | | 17.89 | | 24.07 | | 32.52 | | 30.00 |
| Pass 90%.. | | 89.43 | | 79.63 | | 88.62 | | 84.00 |
| Refer Basis.. | | 10.57 | | 20.37 | | 11.38 | | 16.00 |

Indexes to the reliability of the test situations are presented in Table II. Since these tests were designed for screening purposes, the data are in terms of pass or refer. Both per cents and tetrachoric "r's" are given. It will be noted that the reliabilities are higher when 90 per cent is used as "passing."

**Table II**

**Summary of Data on Reliability**

**(Per cent in each of four categories and Tetrachoric "r")**

| Setting | Passing Basis | Pass Both | Refer Both | Refer 2nd Pass 1st | Refer 1st Pass 2nd | Pass or Refer both | Tetrachoric "r" |
|---|---|---|---|---|---|---|---|
| .50 | 100% | 70.36 | 18.52 | 5.56 | 5.56 | 88.88 | .905± .02 |
| .50 | 90 | 77.78 | 16.67 | 3.70 | 1.85 | 94.45 | .957± .01 |
| 2.50 | 100 | 52.00 | 20.00 | 18.00 | 10.00 | 72.00 | .603± .09 |
| 2.50 | 90 | 78.00 | 12.00 | 4.00 | 6.00 | 90.00 | .900± .02 |

## Summary

The findings may be summarized as follows:

1. When the slide holder was set at the equivalent of plus .50, approximately ten per cent of the cases were referred (i.e., they received a score of less than 90 per cent) on the first testing. The findings were taken by means of a ten-item, far-point slide.

2. When the slide holder was set at the equivalent of sixteen inches, approximately eleven per cent of the cases were referred (i.e., they received a score of less than 90 per cent) on the first testing. These findings were taken by means of a ten-item near-point slide.

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# Part IX

## Fusion

Three levels of fusion have been described by Betts.[1]

1. *First degree fusion.* Simultaneous vision usually is referred to as first degree fusion. When simultaneous seeing with both eyes is not present, stereoscopic vision cannot be measured.

2. *Second degree fusion.* The superimposition of images usually is referred to as second degree fusion.

3. *Third degree fusion.* Depth perception, or stereopsis, usually is referred to as third degree fusion. One of the chief advantages of having a pair of eyes is the ability to perceive depth, or to view objects tri-dimensionally. In short, stereopsis is "the visual perception of solidity and depth."

Stereoscopic vision is considered to be one of the highest forms of binocular seeing. This is achieved by the interpretation of disparate images.

Bielschowsky called attention to a fallacy in the thinking of those who fail to consider psychophysiological factors in fusion (5, p. 10):

> " . . . all the ocular muscles participate in producing every movement of the eye. A certain motor impulse brings about the contraction of one group of muscles, called agonists, and at the same time the relaxation of the other group, called antagonists. Sherrington demonstrated that the stimulation of the cortical center for a lateral movement causes the contraction of the agonists as well as the relaxation of the antagonists. This relaxation takes place even in cases in which the agonists are not functioning, whether from a total paralysis of those muscles, or because their nerves have been cut experimentally. This fact is important, because the lengthening of the antagonists in the normal act of vision was formerly understood as a passive stretching caused by the contraction of the agonists which had to overcome the resistance of the antagonists. In consequence of this wrong supposition the ophthalmologists thought that the function of a paretic muscle might be improved by weakening the antagonists. But by doing this they only added a postoperative weakness of the antagonists to the paretic weakness of the agonist, without improving the function of the latter."

This point of view is also expressed by Peter (13, p. 80):

> "In a study of binocular single vision, inasmuch as an object which falls on corresponding retinal points is received as a single impression in the cortical visual center, one might on first thought regard the act as a simple automatic act, which needs no further explanation. That it is more than a simple automatic act is best demonstrated by a prism experiment. If, during this act a 4 diopter prism is placed before one eye, base in, the discomfort caused by the displacement of the image of this eye, is followed unconsciously by a corresponding rotation of the eye outward and singleness of vision is restored. There is then a desire or a love for single vision. It is not a purely automatic act, but an active definite effort toward a definite end. This desire for singleness of vision we call a fusion faculty. By some the abhorrence of double images is thought to be the force which impels toward single vision. Van der Hoeve, therefore, coined the phrase 'diplopia phobia' as expressive of the condition. This negative way of regarding the phenomenon but implies that there should be a positive force or ability to overcome diplopia. It is more expressive of a real condition to speak of a love for or a desire for fusion. Whether we call the force which impels to fusion a 'fusion faculty' or a 'fusion center' is purely an academic question with the weight of the argument in favor of the former. We know of no such center and it is safe, therefore, to speak of a 'fusion faculty.' It is noncommittal. We will regard it, therefore, as a positive force which impels, when possible, to single vision."

The Betts Fusion Tests were published as a supplementary set of tests with the 1936 revision of the Visual Sensation and Perception Tests of the Betts Ready to Read battery. The administration of the basic battery and the Betts fusion tests is described in *The Prevention and Correction of Reading Difficulties.*[4] These tests provide an index to second-degree fusion. The size of each target for both the near-point and far-point tests follows (4, p. 36):

| Slide | Diameter (Millimeters) |
|---|---|
| A | 1 |
| B | 2 |
| C | 4 |
| D | 6 |
| E | 8 |
| F | 10 |
| G | 15 |
| H | 20 |

Dr. Skeffington and his associates (12, p. 3) use the following percentage values to record level of achievement:

| Size of dots | Percentage |
|---|---|
| 1 mm. | 100% |
| 2 mm. | 90% |
| 4 mm. | 80% |
| 6 mm. | 70% |
| 8 mm. | 60% |
| 10 mm. | 50% |
| 15 mm. | 40% |
| 20 mm. | 30% |

The Betts Fusion Tests may be used in three ways: First, they may be used by psychologists, teachers, and nurses to *screen* out, or to detect, cases needing referral to a specialist. As will be shown in subsequent publications, many of these referral cases present difficulties largely of a psycho-physiological nature. Second, they may be used to secure an index to the size of type (and other typographical factors) required for reading materials. Third, they may be used by the refractionist or orthoptist to demonstrate progress to the patient. Since these supplementary sets of fusion tests are designed to serve as a scale, or a graded series of tests, they are useful for both analysis and motivation.

Skeffington and his associates (12, p. 2), justify the use of these tests of second degree fusion as follows:

> "These tests are taken primarily for the purpose of establishing the integrity of the fusion sense and of presenting to the optometrist the picture of the extent of the defenses that have been set up to compensate for the difficulty which has already been uncovered in the analytical routine."

### Findings

Data on the fusion slides used in this study are being reported by Betts.[2] The data on the cases in this study are summarized as a part of that report.

Distributions of the findings on the children in the fifth grades of the Huntingdon, Pennsylvania, Public Schools are presented in Tables I, II, III, and IV.

**Table I**
**Summary of Near-Point Fusion Data**
(First Testing)
Elementary School Pupils
Huntingdon, Pa.
Telebinocular Setting: 16"

| Target | f | % |
|---|---|---|
| A | 80 | 64.0 |
| B | 15 | 12.0 |
| C | 5 | 4.0 |
| D | 8 | 6.4 |
| E | 5 | 4.0 |
| F | 3 | 2.4 |
| G | 2 | 1.6 |
| H | 3 | 2.4 |
| 4 Balls only on all | 4 | 3.2 |
| Total | 125 | 100.0 |

**Table II**
**Summary of Near-Point Fusion Data**
Elementary School Pupils
(Second Testing)
Huntingdon, Pa.
Telebinocular Setting: 16"

| Target | f | % |
|---|---|---|
| A | 36 | 67.92 |
| B | 6 | 11.32 |
| C | 4 | 7.55 |
| D | 3 | 5.66 |
| 2 Balls only on all | 1 | 1.89 |
| 4 Balls only on all | 3 | 5.66 |
| Total | 53 | 100.0 |

**Table III**
**Summary of Far-Point Fusion Data**
(First Testing)
Elementary School Pupils
Huntingdon, Pa.
Telebinocular Setting: Plus .50

| Target | f | % |
|---|---|---|
| A | 64 | 51.2 |
| B | 32 | 25.6 |
| C | 18 | 14.4 |
| D | 1 | .8 |
| E | 3 | 2.4 |
| F | 0 | 0.0 |
| G | 3 | 2.4 |
| H | 0 | 0.0 |
| 4 Balls only on all | 4 | 3.2 |
| Total | 125 | 100.0 |

**Table IV**
**Summary of Far-Point Fusion Data**
(Second Testing)
Elementary School Pupils
Huntingdon, Pa.
Telebinocular Setting: Plus .50

| Target | f | % |
|---|---|---|
| A | 34 | 64.15 |
| B | 4 | 7.55 |
| C | 2 | 3.77 |
| D | 5 | 9.43 |
| E | 2 | 3.77 |
| F | 2 | 3.77 |
| G | 0 | 0.00 |
| H | 1 | 1.90 |
| 4 Balls only on all | 3 | 5.66 |
| Total | 53 | 100.0 |

In order to secure an index to the reliability of the test situation, fifty-three cases were re-checked. The data secured from this re-check are summarized in Tables V, VI, VII, and VIII.

**Table V**
**Summary of Data on Reliability of Near-Point Fusion Tests Using "C" Target as Expected**
(For Habitual Seeing)

| | f | % |
|---|---|---|
| Pass both tests | 39 | 73.6 |
| Refer both tests | 5 | 9.4 |
| Pass, first | 2 | 3.8 |
| Refer, second | | |
| Refer, first | 3 | 5.6 |
| Questionable, second | | |
| Refer, first | 4 | 7.6 |
| Pass, second | | |
| Total | 53 | 100.0 |

**Table VI**
**Summary of Data on Reliability of Near-Point Fusion Tests Using "D" Target as Expected**
(For Habitual Seeing)

| | f | % |
|---|---|---|
| Pass both tests | 44 | 83.0 |
| Refer both tests | 3 | 5.7 |
| Pass, first | 1 | 1.9 |
| Refer, second | | |
| Refer, first | 5 | 9.4 |
| Pass, second | | |
| Total | 53 | 100.0 |

**Table VII**
**Summary of Data on Reliability of Far-Point Fusion Tests Using "C" Target as Expected**
(For Habitual Seeing)

| | f | % |
|---|---|---|
| Pass both tests | 39 | 73.6 |
| Refer both tests | 6 | 11.3 |
| Pass, first | 5 | 9.4 |
| Refer, second | | |
| Questionable, first | 1 | 1.9 |
| Refer, second | | |
| Refer, first | 2 | 3.8 |
| Pass, second | | |
| Total | 53 | 100.0 |

**Table VIII**
**Summary of Data on Reliability of Far-Point Fusion Tests Using "D" Target as Expected**
(For Habitual Seeing)

| | f | % |
|---|---|---|
| Pass both tests | 44 | 83.0 |
| Refer both tests | 4 | 7.6 |
| Pass, first | 2 | 3.8 |
| Refer, second | | |
| Refer, first | 3 | 5.6 |
| Pass, second | | |
| Total | 53 | 100.0 |

## Summary

1. 76% of the cases fused the near-point "B" targets on the first testing; 76.8%, the far-point "B" targets.

2. 80% of the cases fused the near-point "C" targets on the first testing; 91.2%, the far-point "C" targets.

3. Using the "D" target as an expected, 89.7% of the cases "passed" or "failed" the near-point fusion tests on two consecutive testings; 90.6%, the far-point fusion tests.

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# Part X

## Ametropia

This report deals with one phase of "clearness of seeing." For seeing purposes, the mind demands both *singleness* of image and *clearness* of image. In some cases clearness of image is sacrificed in the interest of singleness of image.

At the present time, a discussion of clearness of image may proceed in one of two directions. First, there are those specialists who make a mechanical approach to the problem. They liken the eyeball unto a camera. The refraction is made and the prescription is given in terms of a "long or short" eyeball. Second, there are those specialists who make a functional approach to the problem. They think in terms of psycho-physiological interferences in the binocular functions rather than in terms of "refractive error." They think of seeing as a learned act rather than as determined by the length of the organ used for the reception of light. The modern educator or psychologist will quickly see that this second approach squares with recent thinking regarding the psychology of learning. In the offices of refractionists as well as in schools, mechanistic principles are being discarded.

Research on "refraction" procedures is very much needed. Both research workers and specialists in this one area are needed by society. For too long has refraction been the professional stepchild. Although techniques of research in this field must be developed, there are now many techniques from allied fields that can be applied effectively. Professional co-operation will not be withheld by educators and psychologists. Until steps are taken to integrate research findings from allied fields and to stimulate and guide research efforts in the study of functional problems of seeing, confusion will reign.

### Concepts of Ametropia

The term *ametropia* requires definition in terms of one's philosophy of refraction. A mechanistic concept of ametropia over-simplifies the problem by implying that seeing difficulties are caused by an ocular anomaly. For example, Harman defines *ametropia* (13, p. 138): "The eyes are not of normal shape; parallel rays are not focused at the macula." A similar definition is given by a physicist (19, p. 65): "Ametropia, . . . is the consequence of structural incongruity between the dimensions of the eye and its refracting power, one or both of these factors being abnormal in the sense that a proper balance does not exist between them." The possibility of "exact" refraction is implied by some specialists (1, p. 114): "An eye is ametropic when its retina does not lie exactly in the principal plane of its dioptric system." The assumption that the eye can be brought to a state of "rest" is made by another specialist (10, p. 66): ". . . *ametropia* . . ., when parallel rays of light are not focused exactly upon the retina with the eye in a state of rest."

From these definitions one would be led to the erroneous conclusion that seeing takes place in the eyeball, that the refractionist should be more concerned about what is happening in front of the retina than what is happening from the retina back.

1. *Length of eyeball?* Statements regarding the relationship of the length of the eyeball to "refractive" status are in need of reappraisal. It is difficult to reconcile these statements with scientific findings and conclusion. Furthermore, authorities such as Duane report (9, p. 199): "In the lower degrees of myopia no noticeable change in the size and shape of the eyeball is found on dissection." This mechanical concept of seeing inherent in the acceptance of the "long and short eyeball" hypothesis has been challenged recently by both refractionists and specialists in physiological psychology.

The eyeballs of individuals do vary in length and shape. Dr. S. E. Whitnall (1, p. 12) reports:

> "The mean of various authors' findings is an anteroposterior dimension of 24.15 mm., a transverse one of 24.13 mm., and a vertical one of 23.48 mm. in adult males; with about 0.5 mm. each less in females. The diameters at various ages from birth to maturity are given by Weiss and Scammon, and the measurements from various authors by Goldnamer. The cornea has an average horizontal diameter of 12 mm. and a vertical one of 11 mm. The weight of the eyeball is about 7 Gm., and the volume 6.5 cc., with a specific gravity of 1.077."

For *extreme* degrees of myopia, Duane reports a change in the size of the eyeball: "The sagittal diameter of the eye, which in emmetropic eyes amounts to 26 mm. at most, may then increase to 32 mm. or over, and the transverse diameter is also somewhat enlarged." (9, p. 199).

The lengthening of the eyeball is used by May (15, p. 368) to explain myopia. However, he continues with these significant statements. "The determining *causes* are associated with the demands which *civilization* and *education* make upon near vision. It is rarely congenital, though there is

often an *hereditary* tendency for its development. It is an *acquired* change which commences at an early age when, during the developing period, the *eyes are used excessively or improperly for near work.*" At this point the question arises, "Is myopia caused by a mechanical lengthening of the eyeball or is it a concession in which the individual gives up far-point clearness in the interest of near-point clearness?"

Dr. Avery De H. Prangen of the Mayo Clinic observed (16, p. 1083): "The status of myopia in ophthalmic practice is still uncertain and debatable. No unanimity of opinion exists as to its nature and treatment." He continued by commenting on Parson's modernization of the concept of myopia (16, p. 1086): "He said that too much stress is likely to be placed on the length of the eye, and he pointed out that the length of the emmetropic eye may vary as much as 2 mm. and the corneal curvature from 6 to 8.5 mm. without affecting the refractive error." The article is concluded by this significant statement (16, p. 1095): "The mechanical theory (elongated globe) of myopia is untenable."

Like myopia, hyperopia is subject to many interpretations. Pronouncements such as this are found frequently in the literature (1, p. 115): "Either the dioptric power is too weak for the length of the eye or, the power being normal, the eye is too short." In contrast, Skeffington and his associates take a more tenable position by defining hyperopia as "the area of compensation (delayed redintegration) between focus and triangulation reflexes, learned to protect the mechanism of focusing against changes taking place between reflexes." Regarding hyperopia, Prangen draws two conclusions: First, "An adequate hyperopic reserve in young persons seems essential as a protection against the development of myopia." Second, "Children who have low hyperopia should be watched. They may not be as normal as they commonly are considered to be." In short, refractionists are finding it necessary to revise their thinking regarding the relationship between the length of the eyeball and "refractive" status.

The mechanical approach to the investigation of "refractive errors" leads one to the study of the length of an eyeball. The functional approach emphasizes accommodative-convergence (focus-triangulation) relationships, concessions, compensatory behaviors, and the like. And again, the mechanist uses lenses to compensate for eyeball abnormalities while the psycho-physiologist uses a lens to change the light stimulus to a nervous system. A few simple refractive procedures (usually at the far-point) provide sufficient information to satisfy one who makes a mechanical approach to refraction. On the other hand, the psycho-physiological approach requires a careful and extended visual analysis to determine the integrity of the visual reflexes.

In spite of the fact that the cause, or causes, of myopia and hyperopia is a moot question, the mechanical concept of seeing is handed down to schools by the authors of books on psychology and on physical hygiene. Without revision for generations, illustrations of hyperopia and myopia by means of long and short eyeballs are included in these books. The "hopeless" prognosis implied continues to be a psychological barrier to the scientific study of the problem.

2. *Exact refraction?* In many instances, both specialists and laymen have been victims of the thinking that an "exact" refraction can be made. Undoubtedly some of this fallacious thinking has been fostered by those who conceive seeing as a mechanical process. The term "exact refraction" is in need of clarification. Research workers soon develop a statistical concept of human behavior. They deal with measures of dispersion as well as with measures of central tendency. In other words, averages provide only one clue to understanding a problem, variability provides another. The reliability of a finding is determined by a number of factors including the emotional and physical status of the individual. "Exact" refraction is a hypothetical consideration to a scientist.

If "exact" refraction were possible and if corrections based on an "exact" refraction solved all seeing problems, then research workers would not be confronted with the necessity of validating a number of criteria for determining the need for corrections. For example, recent reports of *significant* studies include a list of criteria used for determining the need for a correction. It is generally assumed that not every fifth grade child with one diopter of "hyperopia" requires plus spheres for either nearpoint or far-point seeing activities. Other considerations must be made. These include symptoms, the syndrome of findings, and the like.

A few days' experience in a reading clinic would very quickly disillusion those who believe that an "exact" refraction is possible or that a prescription based on an "exact" refraction is the solution to all seeing difficulties. Occasionally a reading clinic case will bring to the clinician seven pairs of glasses, none of which is "right." A check-up often reveals that the case has been refracted by specialists with excellent reputations, each prescribing a slightly different correction. These cases usually receive greater satisfaction when they are referred to specialists who concern themselves with the psycho-physiological factors involved rather than with only "exact" refraction.

The success of orthoptists with seeing problems merits consideration. It has been demonstrated that the refractive status can be altered by orthoptics as well as by wearing lens corrections. Do

orthoptics change the length of an eyeball? Does the wearing of a lens correction modify the shape of an eyeball? If not, how can one entertain a concept of "exact" refraction?

Those using either cycloplegic or non-cycloplegic techniques can fall into the error of thinking "exact" refraction. Many cases will not accept the "full" correction found to be needed by "exact" refraction techniques. Then, this requires a *subjective estimate* of what lens power can be accepted. It is, therefore, difficult to understand what is meant by the term "exact refraction." One concludes with a full-fledged semantic problem of "Find the referent."

Specialists in physical optics have contributed generously to an understanding of certain aspects of seeing problems. Through their efforts, refraction techniques and devices have been improved and progress has been made in the development of lenses. This is only a part of the problem, however. Seeing involves an individual and his environment; therefore, the vast amount of research and thinking in physiological optics and psychological optics should be brought to bear on the general problem. The eyes are a part of the human body.

3. *State of rest?* In discussions of *ametropia,* frequent mention is made to the eye in a "state of rest" or "in complete repose." Such statements may be either semantic slips, or involvements, or gross misinterpretation of scientific findings. If the eye could be put in a state of rest for refractive purposes, what would be measured? Within the writer's knowledge reports of the validity of such findings have not been published.

Dr. Walter B. Lancaster's discussion of tonus in regard to extrinsic muscles undoubtedly has a bearing on a concept of ametropia (14, p. 2):

> "In regard to the subject of heterophoria, much has been written about the position of the eyes at rest. This introduces a misleading conception. What one measures in measuring heterophoria is not the deviation when the eyes are at rest, because as a matter of fact, they never are at rest; that is, the muscles are never inactive, at rest, totally relaxed, not contracting. It is easy to show that even in sleep and in narcosis the ocular muscles are in a state of tonus, while after death they contract in rigor mortis. Even if one *could* determine the position of the eyes when all the motor nerves to all the ocular muscles are completely paralyzed, this would not clarify the problem of heterophoria. It is essential for a correct conception of heterophoria to keep in mind the fact that the ocular muscles are in a state of tonus, that is, they are being innervated. The position of the eyes, in short, is determined not simply by the anatomic conditions, but by these as modified by innervation of the muscles. What one does in measuring heterophoria is to determine the position of the eyes when fusion is eliminated, not when *all* muscular activity is eliminated. It is the fusion-free position, not the position of rest. Hence it is important to consider tonus."

The fallacy of the static eye has been described previously very ably by Skeffington (18, p. 2):

> "To talk about a static eye is about as sensible as to talk about a static heart. It would mean an ignorance of the known facts of physiology, for no part of the body is ever completely inert. Life is going on all the time. There is a constant building up and breaking down of the tissues of the body. Nervous impulses flow to all parts of the body at all times, bringing their messages and stimulations to the varoius muscles, so that the body may be kept erect, that it may be kept in proper equilibrium and that it may fulfill at every moment its dynamic function."

### Educational Implications

Educators and psychologists have concerned themselves with the relationship between visual sensation and perception findings and educational adjustment. The industrial psychologist, of course, is interested in the relationship between visual status and job requirements. So far as the "non-specialist" in seeing is concerned, then, there are two important implications for visual findings; health and psycho-educational adjustment. Recently, greater emphasis in schools has been placed on the educational implications of the findings.

As a result of intensified interest in seeing problems, controversies have arisen. Two groups have contributed to confusion in thinking. The *first* group embraces the *specialists* in seeing. Regardless of whether or not the refractionist has had medical training, some entertain anatomical concepts of seeing while others think in terms of psycho-physiological concepts of seeing. The *second* group contributing to this confusion is composed of educators and school psychologists. These non-specialists in visual sensation and perception have based their investigations and statements on the confused beliefs of specialists and upon erroneous assumptions.

In regard to the use of the Visual Sensation and Perception Tests of the Betts Ready to Read battery, Betts (3, p. 13) pointed out that they provide indexes to psycho-physiological factors: "Those who reject, therefore, any consideration of psycho-physiological factors in seeing will find that these tests screen out a certain percentage of individuals for referral for whom correction or guidance will not be given."

The situation in which educators find themselves has been described by Betts (3, p. 4):

> "As evidenced by statements in magazine articles and research reports considerable confusion exists regarding the relationship between seeing and reading. Reading and seeing are somewhat similar in that both are primarily central processes. However, to attempt to predict reading ability on the basis of certain tests of seeing is quite beside the point. Such studies may indicate the relationship

between these factors—reading and seeing—that exists for certain types of cross-sections of the general population, but the problem of visual *readiness* for near point activities still remains to be studied. The investigation of *readiness* and the study of *abilities* requires somewhat different approaches."

As a result of his investigation regarding the relationship between ametropia (using the Betts tests) and reading achievement, Fendrick concluded (12, p. 50):

"Telebinocular tests of reading readiness isolated a significant difference between good and poor non-phonetic readers that ascribed a higher frequency of astigmatic anomalies to the reading disability cases. This variation was particularly significant inasmuch as no differences existed between the groups taught by the phonetic method. These variations produced by astigmatic anomalies were, however, undoubtedly reflected in the visual acuity measurements."

He continued with the comment (12, p. 51): "Although ametropia exists among pupils not manifesting reading disability, its existence cannot be condoned as its presence unnecessarily handicaps the child even though immediate effects may not be evident."

### Screening Tests

The tests of sharpness of image used in this study are mounted on two standard stereoscopic slides for use with the Telebinocular. The twelve golden balls on each slide are divided so that six balls above the white line are seen with the right eye and the six balls below the white line are seen with the left eye. In the 1934 edition, each ball had three lines. In order to forestall guessing, the 1936 edition of these tests has been revised so that only three balls before each eye contain three lines each. (This test has been modified slightly for the 1941 edition.) This necessitates the use of two slides in order to test the six principal meridians of each eye by means of a ball containing three lines. The use of three lines for the *test* balls is necessary in order to insure comparable and consistent results. The "*dummy*" balls have one, two, or four lines. *Only the responses on the test balls, containing three lines, are recorded.*

In 1937, a special set of near-point slides (Slides DB-7F and DB-7G) were developed by reducing the size of the far-point slides. In terms of physical optics, the near-point slides required a reduction in the proportion of 19/27. Theoretically the plus 3.00 setting of the slideholder requires the use of a target 9.2 mm. in diameter. By using a round diaphram in the reducing camera, the far-point targets reduced proportionally and, therefore, did not require an adjustment in the separation of the lines for the test targets for use at the near-point.

The number of lines in each ball on the DB-7C and DB-7F slides is as follows:

**Chart I**

| | O. S. Target | Number of Lines | O. D. Target | Number of Lines |
|---|---|---|---|---|
| Test ball ..... | A | 3 | 1 | 3 |
| Dummy ball ..... | B | 4 | 2 | 1 |
| Dummy ball ..... | C | 2 | 3 | 2 |
| Test ball ..... | D | 3 | 4 | 3 |
| Test ball ..... | E | 3 | 5 | 3 |
| Dummy ball ..... | F | 1 | 6 | 4 |

One-half of the balls on a given slide (e. g., DB-7C) contain three lines while on the companion slide (e. g., DB-7F) the other half of the balls contain three lines. In short, the use of the two slides is equivalent to using one slide with three lines in each of the twelve balls.

The number of lines in each ball on the DB-7G and DB-7D slides are as follows:

**Chart II**

| | O. S. Target | Number of Lines | O. D. Target | Number of Lines |
|---|---|---|---|---|
| Dummy ball ..... | A | 4 | 1 | 1 |
| Test ball ..... | B | 3 | 2 | 3 |
| Test ball ..... | C | 3 | 3 | 3 |
| Dummy ball ..... | D | 2 | 4 | 2 |
| Dummy ball ..... | E | 1 | 5 | 4 |
| Test ball ..... | F | 3 | 6 | 3 |

The spacing of the three lines in this test has been so calculated that it represents the distance between the parts of the smallest letters which a person with normal vision should be expected to read. The lines cross the yellow balls in six different meridians with an angular difference of 30 degrees. They are grouped in vertical pairs, the lines of each upper ball being at right angles to those of the ball immediately below it. Thus the lines in No. 3 and in "C" are at 180 degrees as cylinders are computed, while in No. 6 and in "F" just below No. 3 and "C" respectively the lines are at 90 degrees. If the lines in No. 3 are reported blurred while those in No. 6 are clear and all other lines are clear, the indication is astigmia in axis 180.

It sometimes happens that the lines in two balls are blurred while those in the balls above or below are clear. Both upper and lower balls of the remaining pair should be clear. In this case the axis of astigmia will probably be found somewhere between the blurred meridians. For example, No. 2 and No. 3 are reported clear while No. 5 and No. 6 are reported blurred. No 1 and No. 4 are clear. The astigmatic axis probably lies between 90 and 120. Whenever members of vertical pairs are reported as equally blurred the indication is need for spherical correction.

The angle of the meridian for each test ball is as follows:

**Chart III**

| Target O.D. | Target O.S. | Axis |
|---|---|---|
| A | 1 | 60 |
| B | 2 | 30 |
| C | 3 | 180 |
| D | 4 | 150 |
| E | 5 | 120 |
| F | 6 | 90 |

The "sharpness of image" slides of the Betts Ready to Read battery were designed as monocular tests. Since the left eye target and the right eye target occupy the lower and the upper parts respectively of the binocular field no superposition is possible (unless there should happen to be an unusual amount of left hyperphoria requiring the test to be given by occlusion). Hence, the test is purely monocular and convergence is not a factor.

### Findings

Data on the ametropia slides used in this study have been reported by Betts (4). The findings on the cases used in this study were summarized in that report. The relationship between findings secured by means of the ametropia slides and findings taken by the specialist will be presented in a subsequent report.

Three hundred fifty-two readings were obtained on one hundred twenty-three unselected cases in grade five of The Huntingdon, Pennsylvania, Public Schools. Slides DB-7F and DB-7G (at 16") and DB-7C and DB-7D (at 80") were used. These readings were taken by Agnes S. Austin and Bonnelee Brown of the Reading Clinic, The Pennsylvania State College. Second test findings were secured on fifty-three cases.

Tables I, II, III and IV summarize the results of this study.

**Table I**
Summary of Ametropia Findings
Elementary School Pupils—Huntingdon, Pennsylvania
First Test
(Left eye)

| Classification | Telebinocular Setting 16" f | % | Telebinocular Setting .50-80 f | % |
|---|---|---|---|---|
| Passed all items... | 93 | 75.60 | 79 | 64.21 |
| Passed all but item: | | | | |
| A | 6 | 4.88 | 2 | 1.63 |
| B | 1 | 0.81 | 0 | 0.00 |
| C | 1 | 0.81 | 5 | 4.07 |
| D | 2 | 1.63 | 2 | 1.63 |
| E | 1 | 0.81 | 4 | 3.25 |
| F | 4 | 3.25 | 2 | 1.63 |
| Failed the following number of items: | | | | |
| 2 | 4 | 3.25 | 16 | 13.01 |
| 3 | 2 | 1.63 | 7 | 5.69 |
| 4 | 5 | 4.07 | 3 | 2.44 |
| 5 | 2 | 1.63 | 0 | 0.00 |
| 6 | 2 | 1.63 | 3 | 2.44 |
| Totals | 123 | 100.00 | 123 | 100.00 |

**Table II**
Summary of Ametropia Findings
Elementary School Pupils—Huntingdon, Pennsylvania
First Test
(Right eye)

| Classification | Telebinocular Setting 16" f | % | Telebinocular Setting .50-80 f | % |
|---|---|---|---|---|
| Passed all items... | 95 | 77.24 | 87 | 70.72 |
| Passed all but item: | | | | |
| 1 | 3 | 2.44 | 2 | 1.63 |
| 2 | 1 | 0.81 | 0 | 0.00 |
| 3 | 1 | 0.81 | 2 | 1.63 |
| 4 | 0 | 0.00 | 1 | 0.81 |
| 5 | 6 | 4.88 | 2 | 1.63 |
| 6 | 4 | 3.25 | 3 | 2.44 |
| Failed the following number of items: | | | | |
| 2 | 4 | 3.25 | 9 | 7.32 |
| 3 | 4 | 3.25 | 10 | 8.13 |
| 4 | 3 | 2.44 | 7 | 5.69 |
| 5 | 2 | 1.63 | 0 | 0.00 |
| 6 | 0 | 0.00 | 0 | 0.00 |
| Totals | 123 | 100.00 | 123 | 100.00 |

**Table III**
Summary of Ametropia Findings
Elementary School Pupils—Huntingdon, Pennsylvania
Second Test
(Left eye)

| Classification | Telebinocular Setting 16" f | % | Telebinocular Setting .50-80 f | % |
|---|---|---|---|---|
| Passed all items... | 41 | 77.36 | 37 | 69.82 |
| Passed all but item: | | | | |
| A | 1 | 1.89 | 2 | 3.77 |
| B | 0 | 0.00 | 0 | 0.00 |
| C | 0 | 0.00 | 1 | 1.89 |
| D | 0 | 0.00 | 2 | 3.77 |
| E | 1 | 1.89 | 1 | 1.89 |
| F | 2 | 3.77 | 2 | 3.77 |
| Failed the following number of items: | | | | |
| 2 | 4 | 7.55 | 2 | 3.77 |
| 3 | 2 | 3.77 | 4 | 7.55 |
| 4 | 0 | 0.00 | 0 | 0.00 |
| 5 | 0 | 0.00 | 0 | 0.00 |
| 6 | 2 | 3.77 | 2 | 3.77 |
| Totals | 53 | 100.00 | 53 | 100.00 |

**Table IV**

Summary of Ametropia Findings
Elementary School Pupils—Huntingdon, Pennsylvania
Second Test
(Right eye)

| Classification | Telebinocular Setting 16″ f | % | Telebinocular Setting .50-80 f | % |
|---|---|---|---|---|
| Passed all items... | 43 | 81.12 | 39 | 73.59 |
| Passed all but item: | | | | |
| 1..... | 1 | 1.89 | 2 | 3.77 |
| 2..... | 1 | 1.89 | 0 | 0.00 |
| 3..... | 1 | 1.89 | 2 | 3.77 |
| 4..... | 1 | 1.89 | 0 | 0.00 |
| 5..... | 1 | 1.89 | 0 | 0.00 |
| 6..... | 0 | 0.00 | 2 | 3.77 |
| Failed the following number of items: | | | | |
| 2..... | 2 | 3.77 | 3 | 5.66 |
| 3..... | 3 | 5.66 | 4 | 7.55 |
| 4..... | 0 | 0.00 | 0 | 0.00 |
| 5..... | 0 | 0.00 | 1 | 1.89 |
| 6..... | 0 | 0.00 | 0 | 0.00 |
| Totals ..... | 53 | 100.00 | 53 | 100.00 |

Table V summarizes the reliability of testing in this study. These data are based on fifty-three cases selected at random. Reliability is expressed in terms of the per cent of cases appearing in each of four categories. In the column headed "Basis for Passing": 5+ indicates correct response to five or six (i.e., 5 or more) items, while 4+ indicates correct response to four, five or six (i.e., 4 or more) test items.

**Table V**

Summary of Data on Reliability of the Ametropia Tests

| Eye Tested | Tele. Setting | Basis for Passing | Pass both tests | Refer both | Pass 1st Refer 2nd | Refer 1st Pass 2nd | Pass or Refer both |
|---|---|---|---|---|---|---|---|
| O.S. | 16″ | 5+ | 79.25 | 11.32 | 3.77 | 5.66 | 90.57 |
| O.S. | 16″ | 4+ | 88.68 | 7.55 | 0.00 | 3.77 | 96.23 |
| O.D. | 16″ | 5+ | 83.02 | 7.55 | 5.66 | 3.77 | 90.57 |
| O.D. | 16″ | 4+ | 86.79 | 1.89 | 5.66 | 5.66 | 88.68 |
| O.S. | 80″ | 5+ | 75.47 | 13.21 | 3.77 | 7.55 | 88.68 |
| O.S. | 80″ | 4+ | 84.90 | 9.44 | 3.77 | 1.89 | 94.34 |
| O.D. | 80″ | 5+ | 73.57 | 9.44 | 7.55 | 9.44 | 83.01 |
| O.D. | 80″ | 4+ | 81.13 | 3.77 | 5.66 | 9.44 | 84.90 |

80

## Summary

The relationship between the findings on the screening tests and those from the diagnostic tests will be presented later. Data will also be presented on cycloplegic and non-cycloplegic findings regarding ametropia.

1. The ametropia, or sharpness of image, tests used in this part of the study were designed to secure an index to psycho-physiological factors in clearness of seeing.

2. Approximately 81% of the cases passed all but two of the right eye targets at near point; approximately 79%, the left eye targets.

3. Approximately 78% of the cases passed all but two of right eye targets at distance; approximately 77%, the left eye targets.

4. In each test situation, the findings for the right eye were slightly superior to those for the left eye.

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# Part XI

## Retinoscopy

One of the clearest descriptions of a retinoscope reads (2, p. 2): "Essentially, a retinoscope is a mirror with a hole in it, reflecting light into the patient's eye, which is reflected out again and observed by the operator through the hole in the mirror."

The retinoscope findings for this study were taken both without and with a cycloplegic. Only the pre-cycloplegic findings are reported herein. Regarding the use of cycloplegia, Dr. Donald H. O'Rourke comments (1, p. 268):

> "It is a common belief that skiascopy is only practicable after full cycloplegia or at least mydriasis. For the beginner a dilated pupil and paralysis of accommodation is desirable in cases where no contra-indication to the use of the drug exists.
>
> "For routine refraction work under suitable conditions and with proper illumination, the surgeon, who will give attention to certain details, will soon learn that cycloplegia is not an indispensable requirement for this test. This general statement may be modified by experience and a complete understanding of the principles involved in applying the method."

The practice of retinoscopy is very briefly summarized by Duke-Elder (5, p. 252):

> "The patient, then, sits facing the surgeon at a distance of 1 meter and relaxing his accommodation, gazes straight ahead into the distance, preferably by fixing a spot of light at the far end of the room. The surgeon holds the plane retinoscopy mirror up to his eye and throws the light into the patient's pupil. He then slowly tilts the mirror from one side to the other, and notes the appearance and movement of the light and shadow."

The conditions which obtained for this study are summarized in Table I.

**Table I**
Working Conditions for Retinoscope Findings

| Finding | | Operator's Working Distance | Patient's Fixation Distance | Target |
|---|---|---|---|---|
| "Static" Retinoscopy | (4) | 20″ | 20′ | Vertical line of 20/20 Snellen Letters |
| Dynamic at 20″ | (5) | 20″ | 20″ | Target attached to Copeland Streak Retinoscope |
| Dynamic at 40″ | (6) | 40″ | 40″ | Same as dynamic at 20″ |

Since it is not possible to observe the light reflex from a distance twenty feet (when taking the static retinoscopy findings), it is necessary for the operator to work at a convenient distance. This distance is a matter of personal choice, and is usually one meter or less. The working distance selected is compensated for by the inter-position of a lens as indicated in Table II. For example, an operator working at one meter must subtract one diopter from the total lens before the patient.

**Table II**
Working Distances and Equivalent Dioptric Values

| Distance Metric | Distance English | Dioptric value |
|---|---|---|
| 1 M. | 40″ | 1 D. |
| 66 cm. | 26″ | 1.5 D. |
| 51 cm. | 20″ | 2 D. |
| 33 cm. | 13″ | 3 D. |
| 25 cm. | 10″ | 4 D. |
| 20 cm. | 8″ | 5 D. |

Duane called attention to the objectivity of retinoscopy (4, p. 213): "The determination of the refraction by means of the *shadow test* was discovered by Cuignet, who called it keratoscopy. It is also known as retinoscopy and skiascopy (oklá, shadow). It is the most accurate of our objective methods of determining the refraction—far more so than the determination by the direct method—and has the advantage over the latter that the refraction and accommodation of the observer do not need to be considered."

Three objective findings were taken by means of the retinoscope. The *first* finding has been called erroneously "static" retinoscopy.[1] Since this finding is taken by having the patient fix on a target at twenty feet, it is still referred to as a "static" finding. This finding is taken by both medical and non-medical examiners. For analytic purposes it is compared with the subjective, or manifest, finding.

Dr. A. M. Skeffington was the first in America to translate and to apply to "refractive" problems the vast amount of literature on the psychophysiology of seeing. After having developed a practical analytic technique, he explained the inclusion of retinoscopy as follows (11, pp. 48-49):

> "It will be noticed from the table of expecteds, the net finding in a pair of eyes, not laboring under an excess fatigue at any point of stimulation, is precisely the same under all the retinoscope findings. If such a variation did exist, it is obvious there is being manifested a change in the amount of stimulation being utilized by one of the dual functions of Accommodation and Adduction at that particular point of stimulation, causing an alteration in the amount of innervation being suplied one function or the other, outside of the linked accommodative-adductive relationship.
>
> "This statement, of course, immediately places the interpretation of the retinoscope finding wholly and completely outside of the idea of the determination of the refractive error that may exist in a pair of eyes in the sense of lens applicability. For if it were merely a matter of an eyeball length and a consequent variation from the needed and demanded lens adjustment system, it would be very easy to ascertain this variation, to supply the additional or required lens power and the entire problem would be cared for. This has indeed, in the past, been considered the scope and role of the retinoscope.
>
> "Men have practiced assiduously for years to perfect a technique whereby they might be able, with the retinoscope, to determine exactly the lens power the patient was to wear. So long as the eye was considered an optical instrument, this was a tenable theory and a laudable ambition. With the coming of the realization that the eye is primarily not functioning as an optical instrument would function, then the role of the retinoscope changes radically."

Halgren's explanation of the far-point retinoscopic finding appears to be consistent with a psycho-physiological approach to the study of seeing problems (8, p. 9):

> "With the patient's eyes focused at 20 feet and one eye blocked off (by means of the operator's head) the accommodative-adductive relationship is destroyed. In over correcting with plus lens and reducing to a neutral, we are measuring, objectively, the inhibition of accommodation free from its fixed association with adduction and *not a refractive error*. It represents the 'area of tolerance' of the accommodative reflex that is not held in fixed association with adduction."

Dvorine cautions against using the far-point retinoscope finding as a verification of the subjective (manifest or basic formula) (6, pp. 35-36): "If the static retinoscopic finding is similar to the subjective, it loses its diagnostic value because the test is not a measure of skill on the part of the refractionist to approximate, as closely as possible, a correction which would correspond to the subjective formula, but is, instead, a study of accommodative and adductive response to monocular stimulation as compared to binocular stimulation of the subjective test. An erroneous idea exists in the minds of many refractionists that the static retinoscopic finding must correspond with the subjective. Many lay claim to exceptional skill with the retinoscope and say that they can approximate an error to within 0.12 diopter, comparing, of course, their finding with the later subjective acceptance on the part of the patient. Accurate neutralization of the shadows is necessary but the refractionist who can note a skiametric variation from the subjective is by far a more dependable retinoscopist."

A standard technique for checking the validity of a given retinoscope finding is described for the 20 inch working distance (3, p. 2): "The finding is checked by moving the retinoscope 3 inches nearer the patient, and then 3 inches away from your 20-inch mark to ascertain if equal *with* and *against* movement develops."

The second retinoscopic finding is usually referred to as the "dynamic at twenty inches."[2] At this distance the working and fixation distances are the same; therefore, it is unnecessary to compensate for the working distance. For analytic purposes, the net finding (gross finding minus a "lag") is compared with the "static" retinoscopic finding.

[1]This is the No. 4 finding in the analytic technique developed by Dr. A. M. Skeffington and his associates.

Regarding the taking of the gross finding, Dvorine states (6, p. 23):

> "The enormous increase of near point concentration with its demand on the accommodative and adductive functions makes it extremely important for the refractionist to investigate the visual reflex at this distance. Using the static retinoscopic findings in the phoropter, the refractionist directs the patient to fix the small letters or figures on the fixation chart attached to the retinoscope and proceeds to examine first the right eye, then the left eye. Additional plus is added to the static findings in the phoropter to show an against movement when the beam of the retinoscope light is directed into the pupil. The plus is then gradually reduced until no further against motion is noted."

The interpretation of findings taken by means of dynamic retinoscopy is held in question by Duke-Elder (5, p. 273): "Our knowledge of the problems raised in this way, however, is not yet quite sufficient to allow dogmatic conclusions to be drawn from the results, or to assess their real use. The method is of distinct value, however, in that, just as static retinoscopy gives an objective basis for the appropriate correction for distant vision, dynamic retinoscopy provides an objective basis for the optical condition when the eye is focused for near vision, a matter which had hitherto been left entirely to subjective testing."

The third retinoscopic finding is usually referred to as the "dynamic at forty inches."[3] Dvorine justifies the taking of this finding (6, p. 23): "This test is made at an intermediate distance to note whether any existing fatigue is limited to the far point, near point or throughout the entire arc of the eyes' activity."

The relationship of this finding to the correction is noted by Skeffington and his associates (3, p. 2):

> "You will recall that the first law of lens application was 'supply no lens that represents more than the accommodation free of convergence.' That law applies at all points of visual fixation. In this modern industrial world, many workers have occasion to use *precise, visual fixation* at points beyond the ordinary reading distance and yet far inside 'infinity.' If the lens acceptable at far is learned, and then the net-at-near is determined, the practitioner might be tempted to overlook the visual problem developed at the intermediate distance; farther out than reading distance—nearer in than far-point."

### Findings

Table III shows the distribution of the three retinoscope findings: the "static" at twenty feet, the dynamic at twenty inches, and the dynamic at forty inches. This is a summary of data on 236 eyes.

[2]This is the No. 5 finding in the analytic technique developed by Dr. A. M. Skeffington and his associates.
[3]This is the No. 6 finding in the analytic technique developed by Dr. A. M. Skeffington and his associates.

**Table III**
**Summary of Retinoscope Findings**

| | Diopter | "Static" 20 ft. | Dynamic at 20 in. | Dynamic at 40 in. |
|---|---|---|---|---|
| | 6.75 | | 1 | |
| | 6.50 | | 1 | |
| | 6.25 | 1 | 0 | |
| | 6.00 | 0 | 0 | 1 |
| | 5.75 | 0 | 0 | 1 |
| | 5.50 | 0 | 1 | 0 |
| | 5.25 | 0 | 1 | 0 |
| | 5.00 | 1 | 0 | 1 |
| | 4.75 | 0 | 0 | 1 |
| | 4.50 | 0 | 0 | 0 |
| | 4.25 | 0 | 1 | 0 |
| | 4.00 | 1 | 1 | 0 |
| P | 3.75 | 1 | 2 | 0 |
| l | 3.50 | 0 | 2 | 3 |
| u | 3.25 | 0 | 1 | 0 |
| s | 3.00 | 1 | 3 | 4 |
| | 2.75 | 2 | 2 | 2 |
| | 2.50 | 3 | 26 | 3 |
| | 2.25 | 3 | 35 | 3 |
| | 2.00 | 0 | 50 | 28 |
| | 1.75 | 5 | 40 | 33 |
| | 1.50 | 7 | 32 | 46 |
| | 1.25 | 15 | 7 | 37 |
| | 1.00 | 49 | 8 | 26 |
| | 0.75 | 52 | 5 | 14 |
| | 0.50 | 44 | 8 | 8 |
| | 0.25 | 15 | 2 | 3 |
| | Plano | 12 | 4 | 5 |
| | 0.25 | 1 | 2 | 2 |
| M | 0.50 | 1 | 1 | 7 |
| i | 0.75 | 5 | | 4 |
| n | 1.00 | 2 | | 1 |
| u | 1.25 | 7 | | 1 |
| s | 1.50 | 4 | | 2 |
| | 1.75 | 2 | | |
| | 2.00 | 1 | | |
| | 2.25 | 1 | | |
| | Total | 236 | 236 | 236 |
| | M. | 0.697 | 1.908 | 1.363 |
| | S.D. | ± 0.971 | ± 0.884 | ± 0.969 |
| | δ M | ± 0.063 | ± 0.058 | ± 0.063 |

### Test Sequence

From experimental evidence, it appears that the sequence in which tests are administered has a bearing on the validity and reliability of certain findings. The analytical test findings for this study were taken in the following order:

1. Chief complaints.
2. Naked visual acuity for far and near (also with old correction, if any).
3. Near point of convergence.
4. Inter-pupillary distance.
5. Ocular motility.
6. External examination.

7. Habitual lateral phorias for far and near.
8. Retinoscopic findings with fixation at 20 feet, 20 inches, and 40 inches.
9. Subjective findings, and visual acuity (O.D., O.S., O.U.) through the subjective.
10. Induced lateral phoria through subjective.
11. True adduction: blur at 20 feet through subjective.
12. Convergence: break and recovery at 20 feet through subjective.
13. Abduction: break and recovery at 20 feet through subjective.
14. Vertical phoria and ductions at 20 feet through subjective.
15. Induced lateral phoria at 16 inches through subjective.
16. Dissociated cross-cylinder findings, with lateral phoria, at 16 inches.
17. Binocular cross-cylinder findings, with lateral phoria, at 16 inches.
18. Tolerance of adductive stimulation: prism base out to blur out at 16 inches, through subjective.
19. Positive fusional reserve: break and recovery findings with base out prism at 16 inches through subjective.
20. Tolerance of adductive inhibition: prism base in to blur out at 16 inches through subjective.
21. Negative fusional reserve: break and recovery findings with base in prism at 16 inches through subjective.
22. Vertical phoria and duction findings at 16 inches through subjective.
23. Amplitude of accommodation: O.D., O.S., O.U.
24. Positive relative accommodation.
25. Negative relative accommodation.
26. Stereopsis (Betts screening test).
27. Cycloplegic examination.

### Summary

The relationship between the retinoscopic findings will be presented in the next article.

1. The average retinoscopic finding for all cases at distance was plus .697 D. Two hundred, or 84.7%, of the eyes required plus sphere of .25 D. or more. The average amount of plus acceptance for this group of two hundred was .968 D., or approximately 1.00 D.

2. The average retinoscopic finding for all cases at twenty inches was plus 1.908 D. Two hundred twenty-nine, or 97%, of the eyes required plus sphere of .25 D. or more. The average amount of plus acceptance for this group of two hundred twenty-nine was 1.971 D., or approximately 2.00 D.

3. The average retinoscopic finding for all cases at forty inches was plus 1.363 D. Two hundred fourteen, or 90.6%, of the eyes required plus sphere of .25 D. or more. The average amount of plus acceptance for this group of two hundred fourteen was 1.561 D.

4. It appears that "hyperopia" rather than "emmetropia" is the expected at this age level.

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# Part XII

## Relationship Between Retinoscopic Findings*

The chief purpose of this article is to present data on the relationship between retinoscopic findings at the three fixation distances used in this study. This type of study is essential to an understanding of problems involved in the interpretation of the findings. If a correlation of 1.00, or perfect correlation, existed between each two of these three measures, then there would be little, or no need for taking more than one finding. With other statistical assumptions met, a correlation of 1.00 would make it possible to predict either one of the other two test findings from the first.

Those who make a psycho-physiological approach to refractive problems make use of differences among such test findings to analyze a seeing difficulty. On the other hand, those who make a mechanical approach to refractive problems are disturbed by deviations from fixed "expecteds" because of their inability to rationalize the situation. In short, those dealing with functional problems of seeing are looking for deviations because they are aware of psychological and physiological factors, such as emotional balance and body tone, which may have a bearing on the problem.

Table I is a summary of the data on the retinoscopic findings taken at the three fixation distances for this study. This table is a summary of all minus, plano, and plus findings. These findings should not be used as expecteds in refraction because they are based on a cross section of one *unselected* population. Children with both ocular discomfort and seeing difficulties were included. It is interesting to note that an average of approximately 2 D. of accommodation was measurable at 20 inches while approximately .7 D. was measurable at 20 feet.

*A. Sterl Artley, M.A., collaborated with Drs. Betts and Austin in the presentation of Part XII.

**Table I**

Summary of Retinoscopic Findings

| Finding | Mean | S.D. | S. E. of M. |
|---|---|---|---|
| "Static" at 20 feet.... | .697 | .971 | .063 |
| Dynamic at 20 inches. | 1.908 | .884 | .058 |
| Dynamic at 40 inches. | 1.363 | .969 | .063 |

Using the Pearson Product Moment technique (5), a coefficient of correlation (r) was determined for each set (two distributions) of retinoscopic findings. This was done in order to examine the relationships between each set of findings. These data are summarized in Table II. It will be noted that all the correlations (r's) were "high."

**Table II**

Summary of Relationships between Retinoscopic Findings

| Finding | Eye | r | P. E. of r. |
|---|---|---|---|
| "Static" with dynamic at 20″... | O.D. | .93 | ±.008 |
| "Static" with dynamic at 20″... | O.S. | .94 | ±.007 |
| "Static" with dynamic at 40″... | O.D. | .92 | ±.010 |
| "Static" with dynamic at 40″... | O.S. | .94 | ±.007 |
| Dynamic at 20″ with dynamic at 40″ ..... | O.D. | .92 | ±.010 |
| Dynamic at 20″ with dynamic at 40″ ..... | O.S. | .98 | ±.003 |

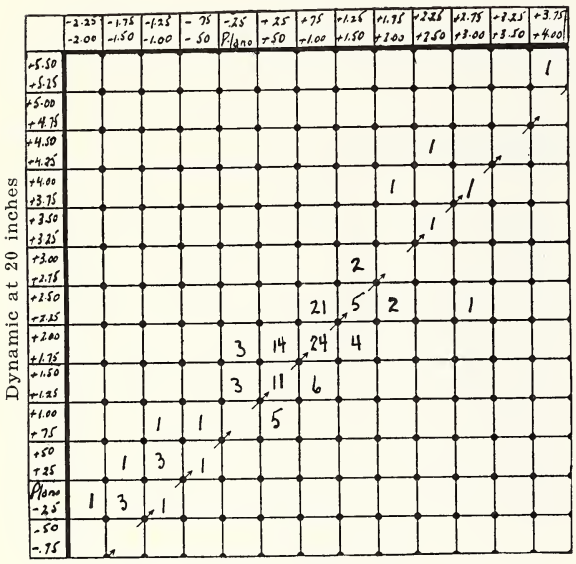
Scattergrams I to VI, inclusive, are graphic presentations showing the relationships between the retinoscopic findings taken at the three fixation distances used in this study. An inspection of the six scattergrams will show the high relationship between each set of findings. It will be observed in Scattergram I (showing the relationship between "static" and dynamic at 20″ findings for O.D.) that the cases distributed themselves along a line at a 45 degree angle. For example, 24 eyes showed .75 or 1.00 D. of plus on the "static" find-

ing and 1.75 or 2.00 D. of plus on the dynamic at 20″. One eye showed a —2.00 or —2.25 for the "static" finding and a —.25 or plano for the dynamic at 20″. And again, another eye showed a plus 3.75 or 4.00 for the "static" finding and a plus 5.25 or 5.50 for the dynamic at 20″. In brief, when one finding was a high plus the other finding *tended* to be a high plus, and when one finding was a high minus the other finding *tended* in that direction.

**Scattergram I**

Relationship between "Static" Retinoscopic findings and Dynamic at 20″ (O. D.)

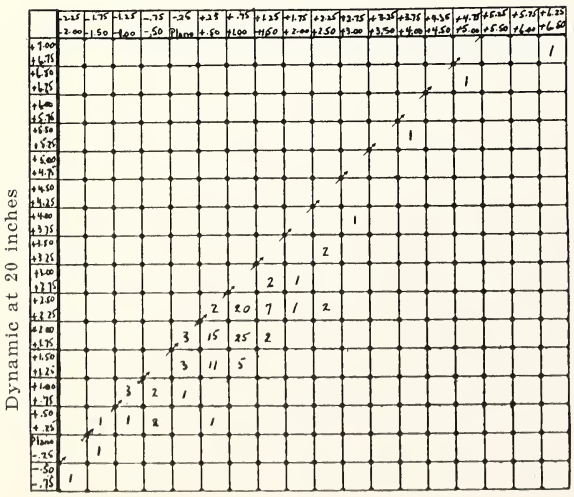
"Static"




**Scattergram II**

Relationship between "Static" Retinoscopic findings and Dynamic at 20″ (O. S.)

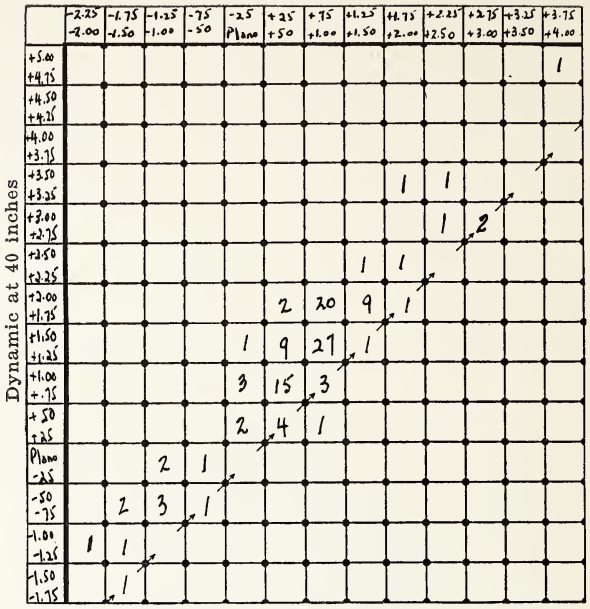
"Static"




**Scattergram III**

Relationship between "Static" Retinoscopic findings and Dynamic at 40″ (O. D.)

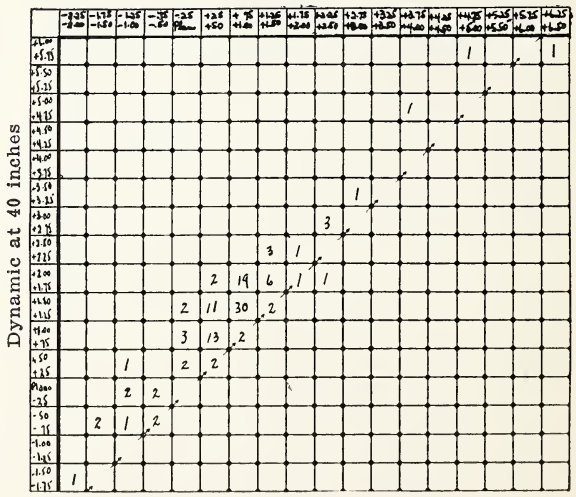
"Static"




**Scattergram IV**

Relationship between "Static" Retinoscopic findings and Dynamic at 40″ (O. S.)

"Static"




**Summary**

There appears to be a high relationship among the retinoscopic findings taken for the three fixation distances used in this study.

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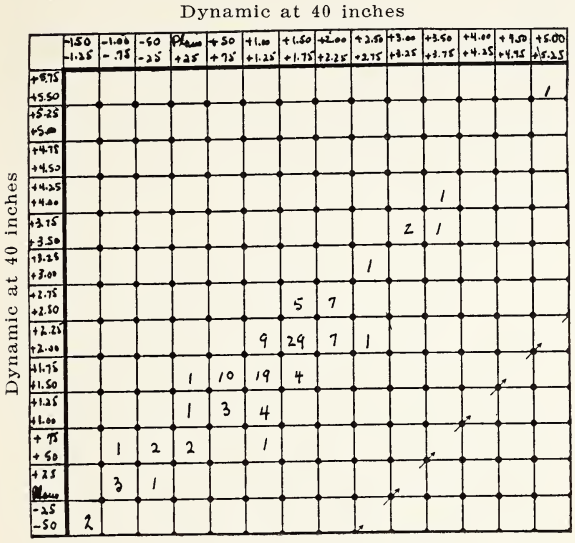
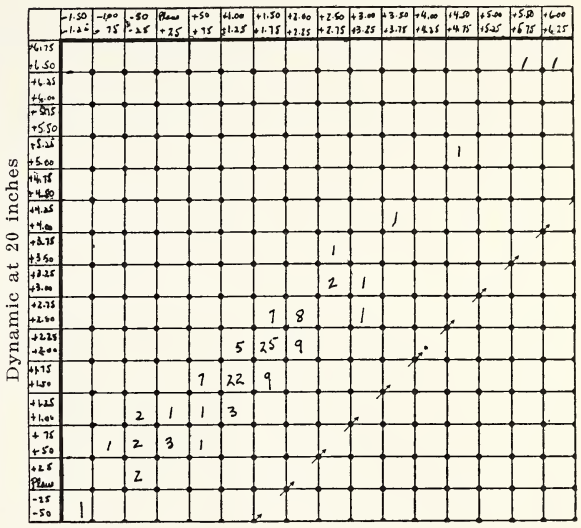
**Scattergram V**

Relationship between Retinoscopic findings with fixation at 20″ and 40″ (O. D.)




**Scattergram VI**

Relationship between Retinoscopic findings with fixation at 20″ and 40″ (O. S.)



# Part XIII

## Manifest, or Basic Formula

Manifest, or subjective, refraction is only one part of an analysis routine. The manifest finding is the basis for determining the final formula required by an individual, but other findings must be considered in arriving at an interpretation of it. For example, "static" retinoscopic findings at distance become significant in the analysis of a seeing difficulty when they differ from the manifest findings. And again, the extent to which the basic formula causes a change in the relationship between accommodation and convergence is determined, at least in part, by means of "induced" phoria findings. Since "refractive error" cannot be treated as an absolute, the manifest findings require interpretation in terms of other findings in the analysis procedure.

The importance of the subjective has been emphasized by Skeffington and his associates (14, p. 1):

> "The Subjective finding—or as it has often been called, 'The Manifest Finding,' is and always has been the heart of refractive technique. Custom has made the Subjective the keystone in the application of the final lens prescription. All the other techniques have been developed to answer the question, 'Will the lens found subjectively be accepted by the patient at this distance—and if not, why?'"

This article deals with the manifest at distance. The manifest is used to determine the amount of accommodation free of association with convergence and to determine the amount and axis of astigmatism.

### Emmetropia

The term emmetropia does not necessarily mean normal. If the acceptance of plano during the manifest is strictly adhered to as a criterion of "normalcy," then only three eyes (or 1.2%) out of a possible 242 were "normal." Using plano retinoscopic findings as a criterion, only twelve (or 5.0%) out of a possible 242 were "normal." It is not probable that 95 per cent to 99 per cent of these children were "abnormal" in a seeing sense. Emmetropia appears to be unusual among the children examined in this study.

Those who believe it possible for the eye to assume a "state of rest" usually define *emmetropia* as that condition of distance refraction that permits parallel rays of light to be brought to an exact focus on the retina. When this is not possible, the condition is termed *ametropia.* They, of course, concede that an emmetropic eye is not always a "normal" eye.

### Hyperopia

A preponderance of cases examined for this study were found to be "hyperopic." Hyperopia appears to be "normal" for children of this age. For the total group, approximately one-half diopter of hyperopia was the average. When the "planos" and myopes were excluded, an average of about one diopter was found. Recently some authorities have pointed out that any significant reduction of hyperopia should be a danger signal for those interested in the prevention of seeing difficulties. In fact, children evidencing less than one-half diopter of hyperopia should be placed under the guidance of a specialist.

At one time it was the general belief that hyperopia was caused by a short eyeball. Hence hyperopia was explained as a lack of "eye-ball" maturity. More recently, however, this rationalization has been found to be questionable, if not untenable in many cases. Seeing is now regarded by many as a learned act. This reasoning has led to the conclusion that hyperopia is the amount of focus (or accommodation) free of association with convergence. As such, hyperopia is a "buffer," or an area of compensation, which is required to protect focus from changes taking place between focus and triangulation reflexes.

### Myopia

Approximately 12 per cent of the cases examined for this study were found to be myopic in one or both eyes. To this group requiring referral and guidance, the "planos" and low hyperopes probably should be added.

If myopia were caused by an elongated eyeball, the possibilities of prevention would be few. However, this mechanistic concept of myopia is being attacked from several quarters. Refractionists have demonstrated the possibilities of orthoptics in the correction of this condition in certain cases. Students of physiological psychology are viewing, at least certain types of myopia as a concession. Research in this area is needed.

### Astigmatism

Most astigmatism is believed to be caused by an irregular curvature of the cornea. This type of astigmatism is called *corneal* astigmatism. Astigmatism caused by a defect in the curvature of the lens is called *lenticular* astigmatism. In addition, a slightly oblique placement of the lens may result in a decentering, or a variation in the refractive index may result in distortion—either producing an astigmatic effect. Some authorities point out that lenticular astigmatism may be neutralized by corneal astigmatism, and vice versa.

Astigmatism is usually appraised by means of the ophthalmometer, the retinoscope, and cylindrical lenses used in the manifest procedure. The ophthalmoscope is sometimes used to detect astigmatism by either a direct or an indirect method.

Duane described the uses of an ophthalmometer as follows (7, pp. 215-216):

> "The ophthalmometer is an instrument for determining the corneal astigmatism by measuring the radii of curvature of the two principal meridians of the cornea, i.e., the meridians which have respectively the greatest and the least refractive power. It does this by measuring the images of an object reflected on the cornea, first in one meridian then in the other. From the size of these images the curvature of the cornea in each of these meridians can be deduced; for the greater the curvature of a convex mirror, such as the cornea represents, the smaller are the reflected images."

Duane recommends the following procedure for the determination of astigmatism by means of retinoscopy (7, p. 215):

> "A more accurate way of determining the astigmatism by the shadow test is to ascertain the refraction of one of the principal meridians with a spherical glass; then leaving this glass *in situ* to place a cylindrical glass with its axis in the meridian thus corrected and keep on changing the cylinder until with the two glasses, spherical and cylindrical, a complete and uniform reversal is obtained in all meridians at once. This method has the advantage of indicating both the axis and the amount of astigmatism with great precision."

The so-called subjective determination of astigmatism is made in a number of ways by competent refractionists. In general, the patient is "fogged" so that he sees with less than 20/20 visual acuity. (Of course, "fogging" lenses are not required for high myopes.) The spheric "fog" is reduced until vision is clear in one meridian, then in the opposite meridian by cylindric lenses. For a target, either an astigmatic dial or Snellen letters are used. The test for astigmatism is made monocularly.

Corrections are usually prescribed for *regular* astigmatism. In regular astigmatism, the two principal meridians are at right angles. When the two principal meridians are crossed obliquely, the condition is termed oblique astigmatism. There appear to be two types of oblique astigmatism. Probably the most common is that in which the principal meridians are at right angles to each other, but not falling at 90 and 180 degrees. A second type, reported to be infrequent, is that in which the principal meridians are not at right angles to each other. This is a form of irregular astigmatism.

The prevalence of regular astigmatism is pointed out by Dr. Cowan (1, pp. 116, 117):

> "A certain amount of regular astigmatism exists in every eye. In order for an eye to be nonastigmatic all refractive surfaces would have to be like an ellipsoid of revolution and all would have to be exactly centered along a common axis. No such condition exists in nature, therefore, there is no such perfect eye. A small amount of astigmatism is negligible so far as its effect on visual acuity is concerned, and such eyes are within normal limits; but when the amount of astigmatism is sufficient to be determined it should be corrected with the appropriate lens."

Regular astigmatism is usually classified as simple, compound, or mixed. Simple astigmatism is further classified as simple hyperopic astigmatism and as simple myopic astigmatism. In simple astigmatism, one of the principal meridians is "emmetropic" and the other principal meridian is either "hyperopic" or "myopic." Compound astigmatism is classified as compound hyperopic astigmatism or as compound myopic astigmatism. In this condition, both principal meridians are either "hyperopic" or "myopic," but varying in degree. In mixed astigmatism, one prinicpal meridian is hyperopic and the other is myopic.

When astigmatism exists in the vertical, or 90 degree meridian (i.e., the vertical curvature is greater than the horizontal), it is said to be "with the rule." This is termed *direct* astigmatism. When it is "against the rule" (i.e., horizontal curvature is greater than the vertical), it is termed indirect astigmatism. All forms of regular astigmatism can be expressed in terms of the minus cylindrical lens which corrects the distortion of the image.

*Irregular* astigmatism does not lend itself to adequate correction. The refraction varies in different meridians and in different parts of the same meridian. It is infrequently found and is generally caused by pathological conditions of the cornea.

### Findings

The distribution of the spherical and cylindrical components of the subjective are reported in Table I. All cylindrical values are reported as minus quantities. It will be noted that these data are presented in terms of eyes rather than of individuals. Of the 121 cases, 49 or 40 per cent did not accept more plus for O. U. Sixty-five cases, or 54 per cent, accepted an additional .25 D. of plus, and 7 cases, or 6 per cent, accepted an additional .50 D. of plus.

**Table I**

Summary of Spherical and Cylindrical Components of the Subjective Minus Cylinders

| | Diopter | Plano | 0.25 | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00[1] | 3.25 | 3.50[1] | 6.00 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plus Spheres | 7.00 | .. | .. | .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. | 1 |
| | 6.75 | .. | .. | .. | 0 | .. | .. | .. | .. | .. | .. | .. | .. | 0 |
| | 6.50 | .. | .. | .. | 0 | .. | .. | .. | .. | .. | .. | .. | .. | 0 |
| | 6.25 | .. | .. | .. | 0 | 1 | .. | .. | .. | .. | .. | .. | .. | 1 |
| | 6.00 | .. | .. | .. | 0 | 0 | .. | .. | .. | .. | .. | .. | .. | 0 |
| | 5.75 | .. | .. | .. | 0 | 0 | .. | .. | .. | .. | .. | .. | .. | 0 |
| | 5.50 | .. | .. | .. | 0 | 0 | .. | .. | .. | .. | .. | .. | .. | 0 |
| | 5.25 | .. | .. | .. | 0 | 0 | .. | .. | .. | .. | .. | .. | .. | 0 |
| | 5.00 | .. | .. | .. | 0 | 0 | .. | .. | .. | .. | .. | .. | .. | 0 |
| | 4.75 | .. | .. | .. | 0 | 1 | .. | .. | .. | .. | .. | .. | .. | 1 |
| | 4.50 | 1 | .. | .. | 0 | 0 | .. | .. | .. | .. | .. | .. | .. | 1 |
| | 4.25 | 0 | .. | .. | 0 | 0 | .. | .. | .. | .. | .. | .. | .. | 0 |
| | 4.00 | 0 | .. | .. | 0 | 0 | .. | .. | .. | .. | .. | .. | 1 | 1 |
| | 3.75 | 0 | .. | .. | 0 | 0 | .. | .. | .. | .. | 1 | .. | .. | 1 |
| | 3.50 | 0 | .. | .. | 0 | 0 | .. | .. | .. | .. | 0 | .. | .. | 0 |
| | 3.25 | 0 | .. | .. | 0 | 0 | .. | .. | .. | .. | 0 | .. | .. | 0 |
| | 3.00 | 1 | .. | .. | 0 | 0 | .. | .. | .. | .. | 0 | .. | .. | 1 |
| | 2.75 | 0 | 1 | .. | 0 | 0 | .. | .. | .. | .. | 1 | .. | .. | 2 |
| | 2.50 | 0 | 0 | .. | 0 | 0 | 1 | .. | .. | .. | .. | .. | .. | 1 |
| | 2.25 | 0 | 1 | 2 | 0 | 1 | 1 | .. | .. | .. | .. | .. | .. | 5 |
| | 2.00 | 2 | 0 | 0 | 0 | 0 | 0 | .. | .. | .. | .. | .. | .. | 2 |
| | 1.75 | 5 | 2 | 1 | 1 | 0 | 0 | 1 | .. | .. | .. | .. | .. | 10 |
| | 1.50 | 8 | 4 | 3 | 0 | 1 | 0 | 0 | 1 | .. | .. | .. | .. | 17 |
| | 1.25 | 21 | 5 | 1 | 0 | .. | 0 | 0 | .. | .. | .. | .. | .. | 27 |
| | 1.00 | 32 | 4 | 2 | 0 | .. | 0 | 0 | .. | 1 | .. | .. | .. | 39 |
| | 0.75 | 50 | 6 | 3 | 0 | .. | 1 | 1 | .. | .. | .. | .. | .. | 61 |
| | 0.50 | 30 | 1 | 2 | 2 | .. | .. | .. | .. | .. | .. | .. | .. | 35 |
| | 0.25 | 3 | 6 | 0 | 0 | .. | .. | .. | .. | .. | .. | .. | .. | 9 |
| | Plano | 3 | 0 | 0 | 0 | .. | .. | .. | .. | .. | .. | .. | .. | 3 |
| Minus | 0.25 | 0 | 0 | 0 | 0 | .. | .. | .. | .. | .. | .. | .. | .. | 0 |
| | 0.50 | 1 | 0 | 0 | 0 | .. | .. | .. | .. | .. | .. | .. | .. | 1 |
| | 0.75 | 3 | 0 | 1 | 1 | .. | .. | .. | .. | .. | .. | .. | .. | 5 |
| | 1.00 | 4 | 1 | .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. | 6 |
| | 1.25 | 2 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 2 |
| | 1.50 | 4 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 4 |
| | 1.75 | 4 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 4 |
| | 2.00 | 0 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0 |
| | 2.25 | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 |
| | [1]4.25 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | 1 |
| | Total | 175 | 31 | 15 | 6 | 4 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | 242 |

Spherical Component:
M. 0.42 (plus)
S. D. ∓1.15
S. E. M. ∓0.023

Cylindrical Component:
M. 0.21 (minus)
S. D. ∓0.21
S. E. M ∓0.043

The average amount of sphere accepted during the manifest examination was 0.42 D. of plus. This mean is the average of all plus and minus findings and, therefore, is subject to misinterpretation. For two hundred fifteen, or 89 per cent, of the two hundred forty-two eyes, .25 D. or more of plus sphere was indicated by the manifest. The average amount of plus sphere accepted was 1.11 D. For twenty-four, or 10 per cent, of the two hundred forty-two eyes, .50 D. or more of minus sphere was indicated by the manifest. The average amount of minus sphere accepted was 1.34 D. (These data are for the 121 cases on whom manifest findings were available.)

Chart I is a presentation of all minus findings on the "static" retinoscope and the distance manifest tests. Each case accepting a minus sphere on the "static" retinoscopic test also accepted a minus sphere on the manifest, and vice versa. Case 3 should be excluded from consideration because she was found to be an esotrope. Where plus spheres were accepted, the finding is indicated with a plus sign. All other figures are minus findings.

[1]Because there was only one spherical finding of minus 2.50 or over, seven class intervals were omitted. In the cylindrical part of the distribution, there were only four findings of more than 2.00 D. and, therefore, thirteen class intervals were omitted in that section of the table.

**Chart I**

Cases Showing Minus Findings on "Static" Retinoscope and Manifest Tests

| Case | "Static" Retinoscopic O. D. | "Static" Retinoscopic O. S. | Manifest O. D. | Manifest O. S. |
|---|---|---|---|---|
| 3 ..... | +2.25 | 2.25 | +1.75 | 4.25 |
| 20 ..... | 1.50 | 1.50 | 1.50 | 1.75 |
| 25 ..... | 2.00 | 2.00 | 1.75 | 1.75 |
| 38 ..... | 1.25 | .75 | 1.00 | .75 |
| 43 ..... | 1.75 | 1.50 | 1.50* | 1.25* |
| 49 ..... | 1.25 | 1.25 | 1.00* | .75* |
| 53 ..... | .75 | 1.25 | .75 | 1.00 |
| 62 ..... | 1.00 | 1.00 | 1.00 | 1.00 |
| 91 ..... | 1.25 | + .50 | 1.25* | + .50* |
| 107 ..... | 1.25 | 1.25 | 1.50* | 1.50* |
| 108 ..... | .75 | .50 | .75 | .75 |
| 109 ..... | plano | .75 | + .25* | .50* |
| 117 ..... | 1.50 | .75 | 1.75* | 1.00* |
| 120 ..... | 1.75 | + .50 | 1.75* | + .25* |

*An asterisk is used to indicate acceptance of an additional plus .25 sphere for O. U.

Table II is a summary of data on the differences between the "static" retinoscopic findings and the manifest findings for 118 cases on whom both findings were available. The average "static" retinoscopic finding (plus, plano, and minus) on all cases examined was a plus .697 D. sphere; the average manifest finding, plus .470 D. sphere. The differ-

ence between the means (averages) was .23 D. In short, the "static" retinoscopic findings tended to be higher than the manifest findings in this population.

The average *plus* sphere finding taken by means of "static" retinoscopy was .968 D.; the average plus manifest finding, 1.106 D. (See Table II.) These means were secured by eliminating those with plano and minus findings. The difference between the means for the plus findings was .14 D., or approximately one-eighth of a diopter. While these means were fairly close, the manifest findings tended to be higher for these cases.

The average *minus* sphere finding taken by means of "static" retinoscopy was 1.208 D.; the average minus manifest finding, 1.343 D. (See Table II.) These means were secured by eliminating those with plano and plus findings. The differences between the means for the minus findings was .14 D, or approximately one-eighth of a diopter. These means were fairly close, with the manifest findings tending to be higher than the "static" retinoscopic findings.

**Table II**

Summary of Differences[2] between "Static" Retinoscopic and Manifest Findings.

| Finding | Mean | Difference between means |
|---|---|---|
| Total "static" retinoscopic findings | 0.697 | .23 |
| Total manifest findings | 0.470 | |
| "Static" retinoscopic plus findings only | 0.968 | .08 |
| Manifest plus findings only | 1.050 | |
| "Static" retinoscopic minus findings only | 1.208 | .01 |
| Manifest minus findings only | 1.217 | |

Of the one hundred twenty-one cases refracted, forty-five, or 37 per cent, manifested astigmatism: twenty-two, or 18 per cent, in both eyes; twelve, or 10 per cent, in the right eye; and eleven, or 9 per cent, in the left eye. Of the two hundred forty-two eyes refracted, sixty-seven, or 28 per cent, of them evidenced astigmatism.

The incidence of astigmatism at each axis is summarized in Table III. The Greens Refractor used in taking these findings was equipped with minus cylinders; therefore, all findings were recorded[3] in terms of *minus* cylinders. It is important to keep this in mind when making interpretations of Table III. For example, in terms of minus cylinder findings, 180° was the axis showing the highest frequency of cases.

[2]Note: Means were based only on the 118 cases (236 eyes) for whom both "static" retinoscopic and manifest findings were available.

[3]The Visual Analysis Record published by the Jewell Press, Bradfordwoods, Pennsylvania, was used to record the findings of the specialist.

**Table III**

Summary of Data on Axis of Astigmatism.

| Axis | O. D. | O. S. | f. | % |
|---|---|---|---|---|
| 180 | 9 | 10 | 19 | 28.4 |
| 170 | 1 | 0 | 1 | 1.5 |
| 165 | 4 | 5 | 9 | 13.5 |
| 150 | 1 | 3 | 4 | 5.7 |
| 135 | 0 | 1 | 1 | 1.5 |
| 120 | 2 | 0 | 2 | 3.0 |
| 105 | 2 | 1 | 3 | 4.5 |
| 100 | 0 | 1 | 1 | 1.5 |
| 90 | 6 | 4 | 10 | 14.9 |
| 75 | 2 | 1 | 3 | 4.5 |
| 60 | 1 | 1 | 2 | 3.0 |
| 45 | 1 | 1 | 2 | 3.0 |
| 20 | 1 | 0 | 1 | 1.5 |
| 15 | 3 | 3 | 6 | 9.0 |
| 10 | 1 | 2 | 3 | 4.5 |
| Total | 34 | 32 | 67 | 100.0 |

**Scattergram I**

Summary of Data on Naked Visual Acuity and Cylindrical Findings

Cylindrical Findings

| Naked Visual Acuity | -6.00 | -3.50 | -3.25 | -3.00 | -2.75 | -2.50 | -2.25 | -2.00 | -1.75 | -1.50 | -1.25 | -1.00 | -.75 | -.50 | -.25 | f | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20/15 | | | | | | | | | | | | | | 4 | 10 | 14 | 20.89 |
| 20/20 | | | | | | | | | | | | | | 6 | 18 | 24 | 36.82 |
| 20/25 | | | | | | | | | | 1 | | 1 | | 4 | 2 | 8 | 11.94 |
| 20/30 | | | | | | | | 1 | 1 | | 2 | 2 | 1 | | | 7 | 10.44 |
| 20/40 | | | | | | | | | | | | | 2 | | | 2 | 2.99 |
| 20/60 | | | | | | | | | | | | | 1 | | | 1 | 1.49 |
| 20/70 | | | | | | | | | | 1 | 1 | | | | | 2 | 2.99 |
| 20/70 | | | 1 | | | | | | | | | | 1 | 1 | 1 | 4 | 5.97 |
| 20/80 | | | | | | | | | | | | | | | | 0 | 0.00 |
| 20/100 | | | 1 | | | | | | | | | | 1 | | | 2 | 2.99 |
| 20/120 | 1 | | | | | | | | | | | | | | | 1 | 1.49 |
| 20/200 | | 1 | | | | | | | | | | 1 | | | | 2 | 2.99 |
| f. | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 3 | 4 | 6 | 15 | 31 | 67 | |
| % | .49 | 1.49 | 2.99 | 0.00 | 0.00 | 0.00 | 0.00 | 1.49 | .49 | 2.99 | 4.47 | 5.97 | 8.96 | 22.39 | 46.27 | | 100.00 |

Scattergram I is presented to show the relationship between astigmatism and naked visual acuity for the cases used in this study. Fifty-seven per cent of the cases manifesting astigmatism had 20/20 visual acuity or better. However, this 57 per cent manifested a low amount of astigmatism (either .25 or .50 D.). Sixty-nine per cent of the astigmatism was of the amount of .50 D. or less. Data presented in this form are subject to misinterpretation. The amount of plus or minus sphere correction is not given. In addition, some of the class intervals where the cylindrical corrections were not found have been omitted to save space.

Relatively small amounts of astigmatism may require correction for reasons other than the improvement of visual acuity. Although his use of the term "eye strain" may be subject of misinterpretation, May offers these significant comments (12, pp. 376-377):

> "With small amounts of astigmatism there may be no reduction in sight; but with greater degrees there is always a *diminuation in the acuteness of vision* both distant and near, varying with the degree and variety of astigmatism. There is commonly considerable *asthe-*

*nopia*, especially upon use of the eyes for near work. These asthenopic symptoms are similar to those occurring in hyperopia, but are apt to be more pronounced and continuous. They vary with the degree and variety of astigmatism, the amount of near work indulged in, and especially the state of the patient's health; a small amount (0.50 D. or even 0.25 D.) will, for instance, often give rise to severe asthenopic and nervous symptoms in a young, delicate, neurasthenic individual. The involuntary accommodative efforts of the ciliary muscle, made to diminish the effects of the error, cause continuous *eye strain* and explain the frequency of asthenopia."

### Summary


1. Approximately 12 per cent of these children accepted minus lenses for one or both eyes.

2. For three eyes plano findings were recorded.

3. The average amount of sphere accepted during the manifest examination was plus .42 D. (This was the average of all plus, plano, and minus findings.)

4. The average amount of plus sphere only accepted during the manifest examination was 1.05 D. (This figure was determined by excluding the plano and minus readings.)

5. A high relationship was found between "static" retinoscope findings and manifest findings. (Of course, the refractionist is concerned with the seeing problems of individuals.)

6. Thirty-seven per cent of these cases manifested astigmatism.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# Part XIV

## Analysis Sequence*

At this point in this series of reports, a summary is presented of the sequence for taking the visual analysis findings. It will be noted that the manifest described in the last report assumes significance as succeeding findings are taken.

The analytical visual routine examination consists of twenty-one primary findings and certain supplementary findings. Groupings of these findings, called syndromes, indicate different situations in the relationship between accommodation and convergence, and serve as guides for the correction of faulty or inadequate relationships.

In brief, the purpose of each finding[1] follows:

1. *Ophthalmoscope:* An examination, with an instrument called the ophthalmoscope, of all of the media (cornea, aqueous, lens, and vitreous) and the eye-grounds for the purpose of discovering opacities in the media, or evidence of pathology in the eye-grounds. It is purely a mechanical investigation and the findings do not appear in any syndrome.

2. *Ophthalmometer:* Finding not taken in this study.

3. *Habitual Phoria at Distance:* This finding is taken through the lenses which the subject wears for distance, or without lenses if the subject does not wear lenses for distance, to measure the habitual association between accommodation and convergence when he is focusing at distance (20 feet). It is a measurement, in prism diopters, of the adductive "area of tolerance."

13A. *Habitual Phoria at Near.* This is the same as Number 3 finding except that it is taken at near point (16 inches).

4. *Static Retinoscopy:* A retinoscopic examination is made with a retinoscope (an instrument consisting of a light source and a mirror). "Static" indicates that the subject is fixing on a target at distance so that accommodation is permitted to relax. The finding is a measure of the area of tolerance in the accommodative reflex when it is not associated with convergence. This area of tolerance is measured by means of a plus lens.

5. *Dynamic Retinoscopy at* 20 *Inches:* This finding is taken the same as the Number 4 finding except that the subject is fixing on the finest type he can read at 20 inches (½ meter). "Dynamic" indicates that accommodation is in full use, but still not associated with convergence. The finding is used as a guide to determine the near point correction.

6. *Dynamic Retinoscopy at* 40 *Inches:* The same technique is used for this finding as for Number 5 except that the examiner works and the subject focuses at 40 inches (1 meter).

7. *Manifest:* This is sometimes called the "Subjective" or "Basic Formula." The eyes are dissociated by the interposition of sufficient prism, base up or base down, before one eye to produce diplopia. Each eye separately is given the lens combination (i.e., sphere and cylinder) which will permit reading the 20/20 line. Binocular vision is then re-established by removing the prism, and the vision is blurred again by the addition of plus lenses in equal amounts to both eyes. This plus is reduced binocularly until the subject is able to again read the 20/20 line. The Number 7 finding is believed to be a measure of the amount of accommodation free of association with adduction (convergence) while the subject is focusing at an accepted infinity, 20 feet. During this test, the astigmatism, if any is present, is corrected by means of cylindrical lenses. It is from the formula, secured by this test, that the distance correction is derived.

*All of the remaining findings are taken through the Number 7 formula except in special cases which need not be considered here.*

8. *Induced Phoria at Distance:* This is called "induced" because it is taken in the same manner

*All office examinations in connection with this study made in Huntingdon, Pa., were taken by Dr. William T. Hunt, Jr. (M.D.)

[1]These findings are described in the order taken. The number before each finding refers to the number used by examiners for identifying specific findings. It will be noted that this is merely an examiner's shorthand method of referring to findings and of dealing with them in identifying the syndrome.

as the Number 3 finding, except through the new basic formula. When compared with the Number 3 finding, this reading shows the change in the accommodation-convergence relationship which has been brought about by the new basic formula.

9. *True Adduction:* The true adduction finding is taken by turning prism base out before the eyes until a slight blur occurs. Previous to taking this finding, the "blur" has been defined for the subject by placing a plus 0.25 D. sphere before each eye. The finding is a measure, in prism diopters, of the amount that adduction ("in-turning") can be stimulated before accommodation is reflexly stimulated. This finding is taken while the subject is fixing on a target at 20 feet.

10. *Convergence:* This is a continuation of the Number 9 finding. It is taken by continuing to turn prism base out before the eyes. The direct stimulation to adduction is increased to the point where diplopia is created, called the "break." It is a measure, in prism diopters, of the extent to which adduction can be directly stimulated. The re-association of accommodation and convergence is brought about by a reduction of the prism power until single binocular vision is established. The amount of base out prism power before the eyes when single binocular vision has been re-established is the "recovery" reading. In short, the Number 9 finding is prism base out to blur, and the Number 10 finding is prism base out to "break" and reduction of prism base out to "recovery."

11. *Abduction:* Abduction is measured by turning prism base in to "break" and reducing the amount of prism base in to "recovery." The finding is a measure in prism diopters of the inhibition to adduction. The "break" indicates the limit to which adduction can be inhibited, and the "recovery" indicates the point at which accommodation and convergence are re-associated.

12. *Vertical Phoria at Distance:* This finding is the measure in prism diopters of the deviation, up or down, of one visual axis from the other.

*Vertical Duction:* The subject is directed to fix on a horizontal line of 20/20 Snellen letters at 20 feet. The prism used in the first part of Number 12 is removed from before the left eye. The other rotary prism is set at zero over the right eye, so that it may be turned either base up or base down. This prism is then turned slowly base down until diplopia is reported. This is the "break." Then the prism is reduced until single vision is regained. This is the "recovery." This "break" and "recovery" are recorded as the right supra-duction. The prism is then turned base up until diplopia is reported, and reduced until single vision is regained. This "break" and "recovery" are right infra-duction. The same procedure is repeated for the left eye.

13B. *Induced Phoria at Near:* The 13B finding is taken exactly like the 13A except that the new Number 7 (basic formula) is before the subject's eyes. The 13A and 13B findings are compared in order to observe any change in the association of accommodation and convergence which has been brought about by the new basic formula.

14A. *Cross-Cylinder, Dissociated:* The target used for this test is a small grid made up of black lines on a white ground. The cross-cylinder is a lens composed of two cylinders; a plus 0.50 D. in one axis and a minus 0.50 D. at right angles to it. When such a lens is placed before the eye, it disrupts the normal focusing process. A cross-clinder is placed before each eye with the minus cylinder axis vertical, and the eyes are dissociated vertically by sufficient prism, base up or base down, to produce diplopia. The subject now sees two grids. Focus (accommodation) and triangulation (convergence) are now dissociated and are said to be "dangling." This condition permits the separate measurement of these basic physiologic reflexes. Thus, inhibition of accommodation free from its usual association with adduction is said to be measured by a plus lens in each eye separately, at 16 inches. This finding, modified by its phoria (15A), is a guide to the amount of plus sphere which is acceptable at the near point.

15A. *Induced Phoria:* This measurement is taken through the plus of the 14A finding, with the grid still being used as a target. It is said to be a measure of the latitude of action of the triangulation reflex when focus is *not* held fixed.

14B. *Cross-Cylinder-Binocular:* The cross-cylinders are used as in 14A but the eyes are not dissociated, so only one grid is seen. This is an acquired reflex and is the measure, by means of plus lenses, of the "play" in the focus reflex while triangulation *is* held fixed.

15B. *Induced Phoria:* This phoria is taken through the plus of the 14B using the reduced Snellen chart as a target. It is again the measure, in prism diopters, of the latitude of action of triangulation reflex while the focus reflex *is* held fixed.

16A. *Tolerance of Adductive Stimulation:* The 16A finding is taken in the same way, and is the measures of the same function as the Number 9 finding. The only difference is that 16A is taken on reduced Snellen type at 16 inches.

16B. *Positive Fusional Reserve:* This finding is the same as Number 10, except that it is taken at near point.

17A. *Tolerance of Adductive Inhibition:* This finding is taken at near point, using the same target as for 16A. The difference is that now the prism is turned base in.

17B. *Negative Fusional Reserve:* This is a continuation of 17A, in that prism base in is increased to "break" and decreased to "recovery." The find-

ing is comparable to the Number 11 finding. It provides similar information for near point that Number 11 gives for distance. It is a measure of the inhibition to adduction at near.

18. *Vertical Phoria at Near:* This phoria finding is taken in the same manner as the Number 12 finding. It provides the information for near point which Number 12 furnishes for distance.

*Vertical Ductions at Near:* The ductions at near point are taken in the same way as those for distance. The target is the horizontal line and dot of Sheard at 16 inches.

19. *Accommodation Free of Association with Convergence.* This finding is taken for each eye separately, and for both eyes together. The target, a group of small letters (0.62M), is placed at 13 inches and minus lenses are turned before the eyes until a slight blurring of the letters occurs. The accommodation measured is the total amount of accommodation free of association with convergence.

20. *Tolerance of Accommodative Stimulation:* Minus lenses are turned before the eyes simultaneously until the subject is unable to read fine print on a target placed at 16 inches. This finding is a measure, in lens diopters, of the ability of the triangulation reflex to block the reflex stimulation from the focus reflx which is being stimulated directly by the minus lenses.

21. *Tolerance of Accommodative Inhibition:* Plus lenses are turned simultaneously before both eyes using the same target and the same distance as for Number 20. In this situation, the finding is a measure, in lens diopters, of the amount of accommodation which can be inhibited without reflexly causing a change in the triangulation reflex.

22. *Cycloplegic**: This examination was made of every subject. It was done by instilling one drop of 5% Homatrophine solution into each eye, followed in ten minutes by one drop of Paredrine solution. One hour was allowed to elapse before the examination was begun. Findings similar to the retinoscopy and the subjective of the visual analysis were taken at twenty feet.

Six supplementary findings were considered in the visual analysis:

1. The lenses which the subject was wearing (if any) at the time of the examination were measured on an American Optical Company "Lensometer" and the prescription was recorded on the examination sheet.

2. Each subject was asked briefly if he experienced any eye discomfort or had headaches. The replies were recorded under "Patient's Complaint."

3. The visual acuity without lens correction was checked at distance on projected Snellen type, monocularly and binocularly, and at near point (14 inches) on the American Medical Association Reading Card, monocularly only. At both distance and near point, the eye which was not being checked was occluded by a black disc.

4. The motility of the eyes was checked, both rotations and versions, by having the subject fix a small transilluminator light while it was held at varying distances from the eyes and moved in a circle of varying diameters, and in different meridians.

5. Near Point of Convergence, or Amplitude of Triangulation: This was measured by instructing the subject to fix a small transilluminator light (as it was moved toward the bridge of the nose along a centimeter rule which was rested against the side of the nose at the bridge) until the light reflex was observed to move from the center of one cornea (or sometimes both). At this point, diplopia is usually experienced. The reading—recorded in centimeters—is the distance of the light from the bridge of the nose, and provides an index to the ability of the subject to converge, or triangulate.

6. External pathology was observed and recorded.

# Part XV

## Subjective, or Manifest, at Near Point

In 1862 Professor H. Snellen of Utrecht gave to the world a scientific and practical means of measuring visual acuity. Although this test has been adapted for the measurement of near-point (reading distance) visual acuity, it is not commonly used in public schools. (And for that matter, it appears that too few refractionists use the near-point visual acuity tests in this modern age.) The interest of educators and school psychologists in the study of near-point problems is forcing all refractionists to consider near-point tests.

It has been estimated that about 80 to 95% of all patients reporting to refractionists present near-point problems. It would be interesting to investigate the amount of near-point seeing activities in relation to the amount of far-point activities required of school children. In both schools and industry, the amount of sustained near-point seeing activities probably is not on the decrease.

Tests are being used in schools and industry to screen out cases in need of referral. These tests detect those presenting functional difficulties at both a near-point and a far-point. In some instances, these referrals are not verified by the tests of the specialist. Investigations by one of the writers reveal that the specialist frequently lacks the equipment and/or the preparation to analyze and correct the difficulties. Contrary to *opinions* of some specialists, this lack of validation of referrals is a problem for the refractionist and not those using the screening tests. Data have been compiled to show clearly where the responsibility lies. The challenge is issued to the refractionists.

From studies made by one of the writers, approximately 35% of those who have been to a refractionist continue on their uncomfortable ways through life. In view of what is known about the capacity for compensation by the human organism, it would be reasonable to suspect that a substantial percentage of the uncomplaining 65% have not received adequate attention. Most, if not all, of the uncomfortable and visually inefficient 35% present unanalyzed near-point problems. Those refractionists who for one reason or another neglect near-point problems are defaulting on their obligations to society.

Although much research is needed in order to study near-point problems and to develop techniques for the analysis of them, the refractionist need not be without analysis techniques. Analysis procedures and very simple instrumentation have been developed to make possible the study of near-point problems. These findings include near point of convergence (amplitude of triangulation), amplitude of accommodation, near-point phorias (habitual and induced), near-point ductions (vertical and lateral), and, not least of all, near-point manifest. These techniques, though easily used, are used by only leading refractionists.

The chief purpose of this report is to present data on the findings from the near-point manifest, or subjective. These findings were taken as a part of a standardized and *practical* visual analysis routine used regularly in the office of the examiner. The purpose of these findings is to determine the amount of sphere acceptable at near. It is believed that these findings are comparable to the far-point manifest finding in that the amount of accommodation (focus) free of association with convergence (triangulation) is measured.

The manifest findings at near-point are taken with the far-point manifest findings in place and by means of a cross-cylinder lens and a target composed of vertical and horizontal lines. Usually a pair of cross cylinders is one of the phorometer accessories. A cross cylinder is simply a lens with a minus cylinder on one axis and a plus cylinder at right angles. This cross-cylinder grid is a modification of the fan dial used at distance.

Two cross-cylinder findings were taken for this study: one with dissociation and one with fusion. Both findings were taken at 16 inches. Farmer's Cross-Cylinder Grid was used for a target. The cross cylinders used had a plus .50 cylinder in one axis and a minus .50 cylinder at right angles to it. In use, the minus cylinder was placed at axis 90.

The first cross-cylinder finding taken was the unfused[1], or dissociated. During this part of the analysis procedure, neither accommodation nor convergence is held fixed. Briefly, this finding was taken as follows: First, the manifest findings for distance were left in the phorometer. Second, dissociation was created by the use of vertical prisms. Third, cross cylinders were placed before each eye with the axis of the minus cylinder at 90 degrees. Fourth, plus sphere was added until the vertical lines of the grid were blacker before each eye. Fifth, the plus sphere was reduced before each eye

[1]This is the 14A finding in the visual analysis procedure developed by Dr. A. M. Skeffington and associates.

until the vertical and horizontal lines were equally black. If they could not be made equally black, the vertical lines were left blacker than the horizontal lines. Sixth, the lens power in the phorometer was recorded as the *gross* finding. Seventh, with the gross finding in the phorometer, a phoria was taken to be used as a basis for determining the lag. Eighth, the *net* findings were calculated.

The second cross-cylinder finding taken was the fused[2], or binocular. In this part of the analysis procedure, convergence is held reasonably constant while accommodation is free to be stimulated. Briefly, this finding was taken as follows: First, the gross findings in the phorometer were arbitrarily reduced. Second, the dissociating prisms were removed. Third, plus sphere was added binocularly until the vertical and horizontal lines were equally black. If they could not be made equally black, the horizontal lines were left blacker. Fourth, the lens power in the phorometer was recorded as the *gross* finding. Fifth, with the gross finding in the phorometer, a phoria was taken to be used as a basis for determining the lag.

### Findings

In Table I, the distributions of the findings of the dissociated and binocular cross-cylinder tests are recorded. It will be noted that these *gross* findings are reported for each eye separately.

**Table I**

**Summary of the Findings of Cross-Cylinder Tests**

| | Diopter | Dissociated f | Binocular f |
|---|---|---|---|
| Plus | 6.50 | ... | 1 |
| | 6.25 | ... | 0 |
| | 6.00 | 1 | 0 |
| | 5.75 | 0 | 0 |
| | 5.50 | 1 | 0 |
| | 5.25 | 0 | 0 |
| | 5.00 | 0 | 0 |
| | 4.75 | 1 | 1 |
| | 4.50 | 0 | 0 |
| | 4.25 | 0 | 0 |
| | 4.00 | 3 | 2 |
| | 3.75 | 3 | 3 |
| | 3.50 | 5 | 2 |
| | 3.25 | 5 | 3 |
| | 3.00 | 5 | 2 |
| | 2.75 | 9 | 5 |
| | 2.50 | 8 | 5 |
| | 2.25 | 19 | 14 |
| | 2.00 | 46 | 18 |
| | 1.75 | 30 | 34 |
| | 1.50 | 26 | 33 |
| | 1.25 | 21 | 28 |
| | 1.00 | 18 | 29 |
| | 0.75 | 4 | 16 |
| | 0.50 | 9 | 12 |
| | 0.25 | 9 | 6 |
| | Plano | 3 | 7 |
| Minus | 0.25 | 0 | 2 |
| | 0.50 | 1 | 3 |
| | 0.75 | 1 | 1 |
| | 1.00 | 0 | 1 |
| | 1.25 | 1 | 0 |
| | 1.50 | 0 | 0 |
| | 1.75 | 1 | 1 |
| | 2.00 | ... | 0 |
| | 2.25 | ... | 1 |
| | Total | 230 | 230 |
| | M. | 1.778 | 1.442 |
| | S. D. | ±0.979 | ±0.979 |
| | S. E. M. | ±0.065 | ±0.065 |

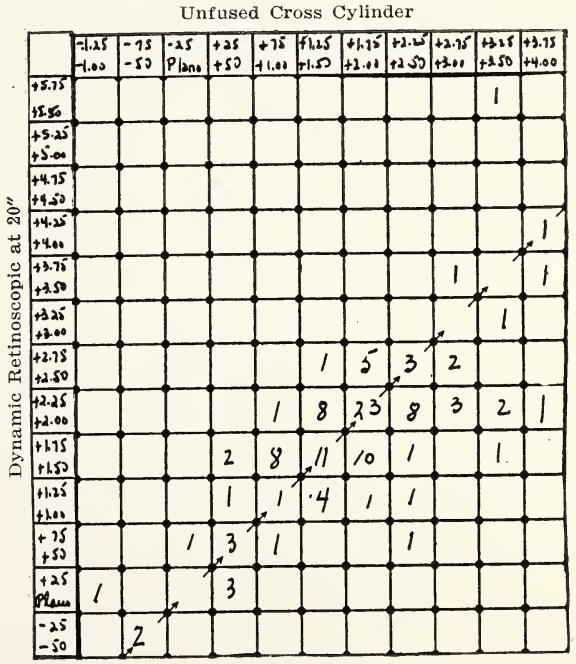
The Pearson Product Moment formula was used to determine the relationship between the unfused, or dissociated, cross-cylinder (gross) findings at 16 inches and the dynamic retinoscopic findings at 20 inches. Scattergrams I and II are used to show graphically the relationships between the findings for right eyes and for left eyes.

### Summary

1. There appears to be a fairly high relationship between the gross cross-cylinder findings taken at 16 inches and the dynamic retinoscopic findings taken at 20 inches.
2. The dissociated cross-cylinder findings tended to be higher than the binocular findings.

**Scattergram I**

Relationship between Dynamic Retinoscopic Findings at 20″ and Unfused Cross-Cylinder Findings at 16″ O. D.



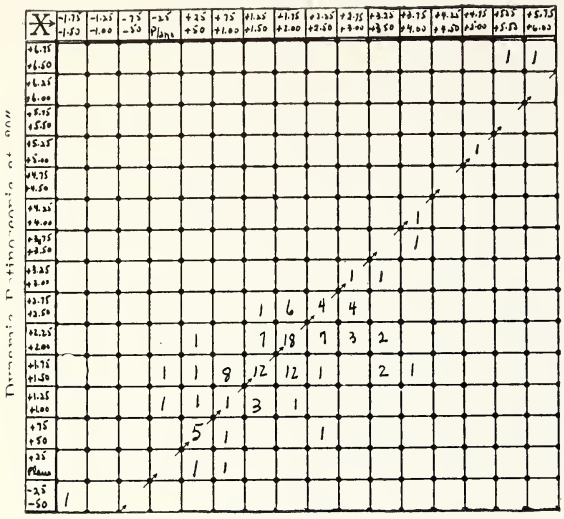

r = .87 ± .015

[2]This is the 14B finding in the visual analysis procedure developed by Dr. A. M. Skeffington and associates.

**Scattergram II**

Relationship between Dynamic Retinoscopic Findings at 20″ and Unfused Cross-Cylinder Findings at 16″ O. S.

Unfused Cross-Cylinder




r = .80 ± .023

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# Part XVI

## Ductions

Duction findings have been taken by refractionists and by clinical workers for many years. The interpretation of the findings, however, has been a principal problem. Those entertaining mechanistic views of refraction have been concerned primarily with testing the strength or the weakness of muscles. With this very narrow concept, these refractionists have found themselves unable to use the findings for analyzing the needs of cases presenting certain types of ocular discomfort or visual inefficiency. On the other hand, there has been an increasing number of refractionists who make a psycho-physiological approach to the analysis of visual difficulties. These refractionists have demonstrated that if an individual has the ability to move his eyes in order to follow a target (as for example in rotations and versions), then he doesn't have "weak" or "strong" muscles. They believe that a duction finding provides an index to the relationship existing between accommodation (focus) and convergence (triangulation).

The functional approach to the analysis of seeing difficulties is being emphasized by Walter B. Lancaster, J. T. Maxwell, A. M. Skeffington and his associates, and others. They are concerned with innervational factors as well as with structural factors. Emphasis on the dynamics of seeing undoubtedly will open new approaches, new techniques, and new interpretations of findings and problems.

One point of view is expressed by May (9, pp. 423-424):

> "In addition to determining the amount of heterophria present for distance and near, it is important to measure the amount of prism the eyes can overcome. *Prism divergence* (*abduction*) is the ability to overcome prisms base in while looking at a distant object; the normal limits of this power are from 4° to 9°; it is constant and gives reliable information of the diverging power, *Prism convergence adduction*) is the ability to overcome prisms base out; it is variable in amount and is of value only when repeated tests show a subnormal power; the normal limits are from 15° to 40°. *Risley's Rotary Prism* is a convenient instrument for measuring these powers."

The psycho-physiological concept of ductions is stated clearly by Dr. A. M. Skeffington (11, p. 99):

> "It must be clearly understood by the ocular diagnostician that the duction is the measure, not of the muscular activity, but of the reserve of energy available to a function. To measure the so-called strength of a muscle would require an instrument such as the Tropometer which literally determines the total available power of the various muscles.
>
> "The duction determination is the measure of the end result of the amount of innervation habitually available as a reserve, to a given function (such as convergence), at a given point of stimulation, at a given time, the quantity conditioned by the existing fatigue."

Duke-Elder admits the possibilities of re-education for certain cases presenting faulty binocular patterns (4, p. 176):

> ". . . . the faculty of binocular vision requires a complex system of inter-related reflexes in the brain which can only be laid down early in life. If a light is presented before a baby's eyes, he will merely fix it momentarily; at two to three weeks of age he will maintain fixation for some seconds with one or other eye but will not converge accurately; it is only at five to six months that he will fix it binocularly and maintain the fixation. Binocular vision is therefore not present at birth, but appears within the first six months of life; and at about the age of six years the faculty of fusion is fully developed. It is only within these formative years that the reflex paths can easily be conditioned by training and educational exercises in cases where the normal development has been deficient; beyond this age greater difficulty is experienced."

In a discussion of the conditioning in the accommodation convergence relationship, Grant reported (6, pp. 59-60):

> "One investigator (14) found, for example, that with a normal eye about 3 diopters of ac-

commodation are needed to see small print clearly at a distance of one-third meter. When a convex lens was introduced accommodation relaxed, but rarely did so completely; for this reason 3 diopters of plus power of the artificial lens could not be successfully substituted; the subject refused to "accept" this much. Why did accommodation not fully relax in the absence of its normal stimulation? It seems clear that in this case the acting stimulus for convergence was also supplying adequate stimulation for the associated (conditioned) reflex of accommodation. For when the stimulation for convergence was abolished by means of a prism, accommodation gave way at once and the 3 diopters of plus were accepted.

"Conditioned convergence may be similarly disclosed by releasing this reflex (with a prism) while the stimulus for accommodation remains active. The amount of convergence reflex persisting after the withdrawal of its natural stimulus will then be a measure of the degree of conditioning established. Tait studied 500 cases between the ages of 10 and 14. The maximum convergent accommodation found was 2 diopters; of accommodative convergence, 21 prism diopters. Eleven subjects had neither of the associated reflexes. Most of the cases were regularly distributed between these two extremes. On the average there were 8-14 prism diopters of associated convergence (accommodative convergence) and 1.50 diopters of associated accommodation. High correlation was present between the two associated reflexes; in very few cases was one present without the other."

The taking of ductions is described very simply by Peter (10, p. 98): "Ductions are obtained by placing increasing strengths of prisms up or down, in or out, before the eye, as the case may be, until the displacement of the images becomes insuperable and manifest diplopia appears."

Rotary prisms were used to take the findings for this study. The use of loose prisms and a trial frame for taking duction findings has been found to be too time-consuming. Dr. Samuel Risley and Dr. Edward Jackson are credited by Dr. Peter (10, p. 102) for contributing the rotary prism technique.

Four sets of duction findings were taken for this study: adduction and abduction at distance; adduction and abduction at near; vertical ductions (supraduction and infraduction) at distance; and vertical ductions at near. Since the subjects used for this study were children, the duction findings were taken through the basic formula, or manifest at distance. (Of course, this procedure is varied for presbyopes when near-point findings are taken.)

Cautions to be observed in taking duction findings may be summarized as follows:

1. Prism should be introduced before both eyes.
2. A tendency to suppress the vision in one eye should be detected and taken into account.
3. Interpretation, in part, should be in terms of the targets used for taking the findings. The size of the target, the amount of printed matter on the target, and the type of reading material, have a bearing on the amount of the finding.

In taking the abduction and adduction findings, Maxwell suggests (8, p. 335):

"In making the duction tests, it is advisable to use prisms over both eyes in order to divide the prism power. If the prisms are used before only one eye, a somewhat different result is usually produced because a strong prism causes a distortion of the retinal image, and, therefore, inhibits fusion."

Near-point seeing problems are in need of more emphasis. Present day seeing activities involve considerable near-point work. In a discussion of adduction, Duane commented (3, p. 303): "It is usually determined for distance only, although it may be also determined for near-point, especially when we are trying to ascertain the effect of prism exercise in relieving an exophoria."

### Terminology

Some of the terms used in the discussion of accommodation-convergence relationships were defined in Part II, Near Point of Convergence. The following is a summary of understandings regarding lateral and vertical ductions.

1. *Lateral Ductions*

   Maxwell states (8, p. 333): ".... , with single binocular vision in effect, the degree to which the fusion faculty is able to resist prismatic action is measured by the duction tests (fusional amplitudes)."

   a. *True adduction*

   Blur findings are taken by some practitioners who make a psycho-physiological approach to the analysis of seeing problems. Dvorine (5, p. 41) states that true adduction is, ".... the measurement, with prisms base-out, of the ability of the adductive function to maintain single binocular fixation and clear vision at infinity without reflexly stimulating the accommodative function into activity." Halgren continues (7, p. 11): "As the adduction is increased in its stimulation, a reflex stimulation is sent to accommodation which must be blocked out or the slightest amount of fatigue would cause a blur. We are then measuring the ability to inhibit this reflex to accommodation as the adduction is being stimulated, and is the measure of the 'area of tolerance' or play between the two reflexes."

   b. *Adduction*

   Adduction is variously referred to as convergence, prism convergence, and positive convergence. This finding is taken with base-out prisms. In regard to convergence at far point, Dvorine (5, p. 41) states the purpose of this finding: "Convergence, with fixation at far point, is the measurement with prisms base-out of the ability of the visual reflex to maintain single binocular

vision." Halgren (7, p. 13) makes this statement regarding positive fusional reserve at the near point: ".... , prism base-out to the break-point stimulates both accommodation and adduction to the limit as it is affected by a direct stimulation to adduction, while the recovery again designates the ability of the two reflexes to reassociate themselves in the visual act when the burden has been reduced."

c. *Abduction*

Abduction is variously referred to as prism divergence and negative convergence. This finding is taken with base-in prisms. Dvorine (5, p. 42) states that this "test is the measure of the maximum ability of the visual reflex to maintain single binocular vision with prisms base-in while the patient is fixing at infinity."

2. *Vertical Ductions*

a. *Supraduction.* This finding is taken by means of prism base down.

b. *Infraduction.* This finding is taken by means of prism base up. Much experimental work will be required to establish the diagnostic significance of vertical duction findings. Peter warns (10, p. 99), ".... in the treatment of hyperphoria little can be accomplished by exercising the vertical balance by means of prisms."

**Expecteds**

1. *Adduction.* For many reasons, opinions regarding desirable norms and/or expecteds also vary widely for adduction findings. Peter (10, p. 102) expects 15 to 18 diopters. Duane (3, p. 304) reports that, "Prism-convergence after a few trials can be run up to 7 to 10 D. or more."

For adduction, Skeffington and his associates have set up certain "minimum expecteds" with the emphasis on the ratio of the recovery to the break and on the relationship of this finding to other findings. As distance, they "expect" a blur of 7 to 9 prism diopters, a break of 19, and a recovery of 10. For distance, the recovery is expected to be at least one-half the break. At near point (16 inches), they expect a break of 21 and a recovery of 15. For near-point, the recovery is expected to be at least two-thirds the break.

2. *Abduction.* Opinions regarding duction expecteds vary. In discussing abduction at 6 meters (target not mentioned) Dr. Peter comments (10, p. 100):

"The average abduction varies from 4 to 8 diopters. In some instances it falls as low as 1 or 2 diopters, and in exceptional cases the abducting power may reach as high as 14 diopters. The latter is exceedingly rare. The average is nearer 4 than 8 diopters. In the same individual abduction is fairly constant from day to day."

Duane (3, p. 304) opines that in a normal case, "Prism-divergence is not less than 2 D. and not over 4 D."

"Minimum expecteds" have been established by Skeffington and his associates. For distance abduction, they "expect" a break of nine and a recovery, or reversion to fusion, of five. For near point (16 inches) abduction, they "expect" a break of 22 and recovery of 18. However, they point out the significance they attach to relationship rather than to sheer "minimum expecteds." For distance, the expected recovery is at least one-half the break for near, three-fourths of the break.

3. *Relationship between lateral ductions.* The analysis of seeing problems apparently calls for an understanding of the relationship between lateral duction findings as well as an understanding of the relationships between accommodation and convergence. "Ductions are signals of the degree of interference taking place between the two reflexes." (12) Sheer amplitude of fusion (i.e., the sum total of abduction and adduction) lacks validation as a significant index to seeing problems.

Peter (10, p. 102) comments:

"The relation of abduction to adduction, when the measurements are taken at 6 meters, is of importance in orthophoria and in the lateral phorias. A ratio of 1 for abduction to 3 of adductions may be considered normal. In abnormal cases great variations are observed. Adduction is mostly in excess of abduction, but case records occasionally show an excess of abduction over that of adduction."

Lower abduction than adduction findings are expected at 6 meters. On this point Peter reasons (10, pp. 100-101): "Conjugate innervations for convergence call forth response almost every moment of conscious wakeful hours, and, therefore, it is in constant demand and training. Divergence, on the other hand, occasionally spoken of as "negative convergence," is rarely called into action because of a total absence of our need for it, and the innervation is therefore a feebly developed innervation."

**Findings**

Table I is a summary of blur findings at 16 inches. Scattergram I is a graphic presentation of the relationship between blur findings at near. These findings were taken with the manifest, or basic formula, before the subject. On the base-out to blur, 52% of the cases reported blur before break. On the base-in to blur, 54% of the cases reported blur before break. On both base-in and base-out tests, 29% of the cases reported break before blur.

**Table I**

**Summary of Blur Findings (At 16 Inches)**

| Response | f | Per cent |
|---|---|---|
| Blur on both | 41 | 35.3 |
| Blur on neither | 34 | 29.3 |
| Blur on 16A[1] only | 19 | 16.4 |
| Blur on 17A[2] only | 22 | 19.0 |
| Total | 116 | 100.0 |

[1]16A finding is base-out to blur at 16 inches.
[2]17A finding is base-in to blur at 16 inches.

**Scattergram I**

**Relationship Between Adduction and Abduction Blur Findings at 16 Inches (41 Cases)**

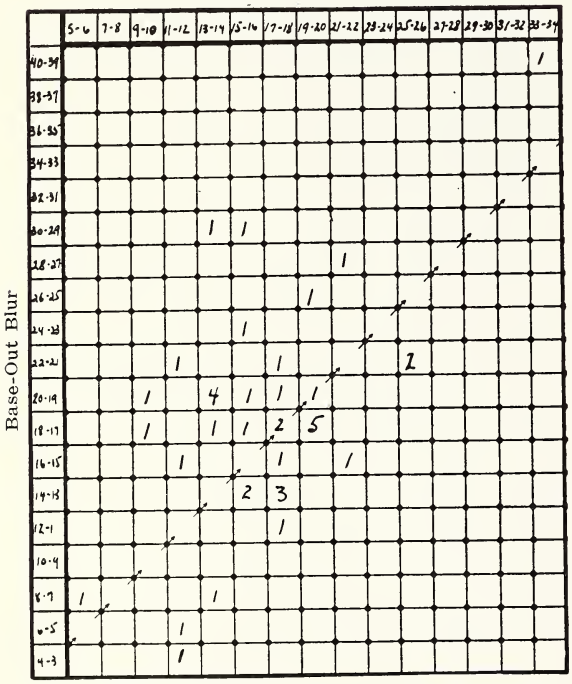



Table II is a summary of data on the break and recovery findings for lateral ductions. Scattergrams II, III, IV, and V are graphic presentations to show the relationships between break and recovery for each of the findings. These relationships are summarized in Table III.

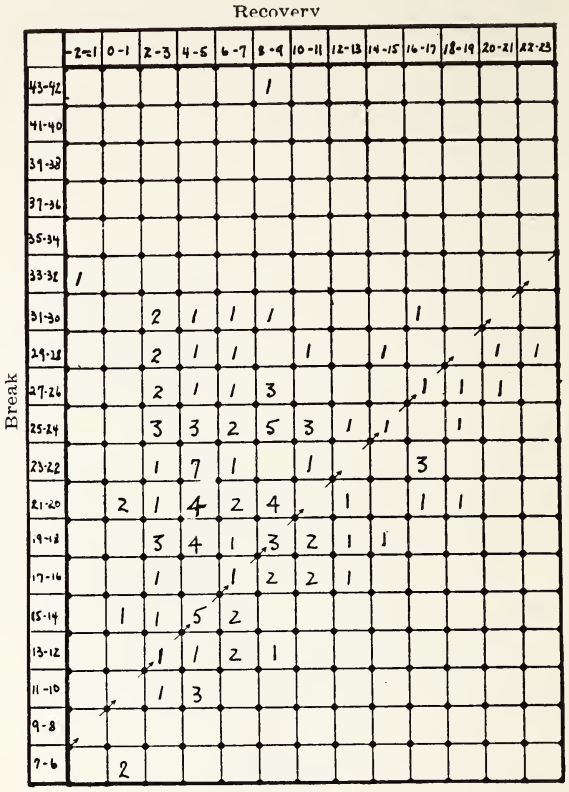
**Table II**

**Summary of Lateral Duction Breaks and Recoveries (116 Cases)**

| | | Break | | | Recovery | | |
|---|---|---|---|---|---|---|---|
| Finding | Distance | M. | S.D. | S.E. of M. | M. | S.D. | S.E. of M |
| Adduction | 20′ | 21.22 | 5.83 | .54 | 7.19 | 4.97 | .46 |
| Abduction | 20′ | 7.10 | 3.20 | .30 | 3.29 | 2.19 | .20 |
| Adduction | 16″ | 21.66 | 5.61 | .52 | 6.40 | 6.58 | .61 |
| Abduction | 16″ | 21.52 | 3.77 | .35 | 12.47 | 6.44 | .60 |

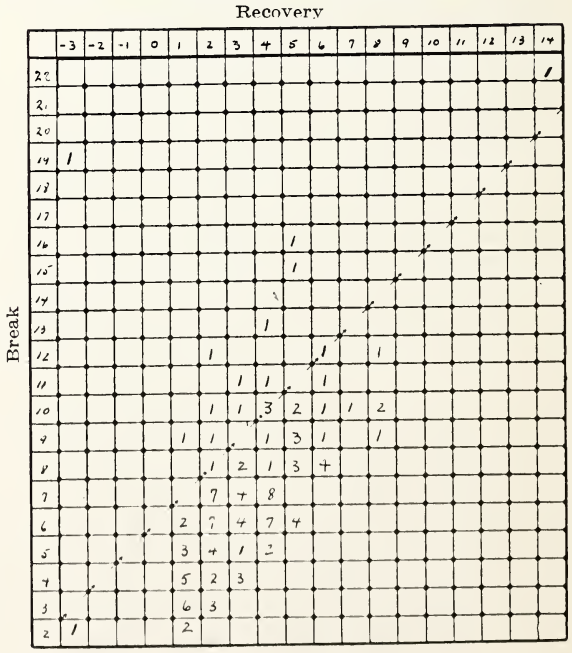
**Scattergram II**

**Relationship Between Base-Out Break and Recovery Findings at Distance (No. 10 Finding for 116 Cases)**




**Scattergram III**

**Relationship Between Base-In Break and Recovery Findings at Distance (No. 11 Finding for 116 Cases)**



## Table III

**Summary of Relationships Between Lateral Duction Break and Recovery Findings (116 Cases)**

| Finding | Distance | r | P. E. of r |
|---|---|---|---|
| Adduction (No. 10) ..... | 20′ | .25 | .06 |
| Abduction (No. 11) ..... | 20′ | .55 | .04 |
| Adduction (No. 16B) ..... | 16″ | .56 | .04 |
| Abduction (No. 17B) ..... | 16″ | .38 | .05 |

## Table IV

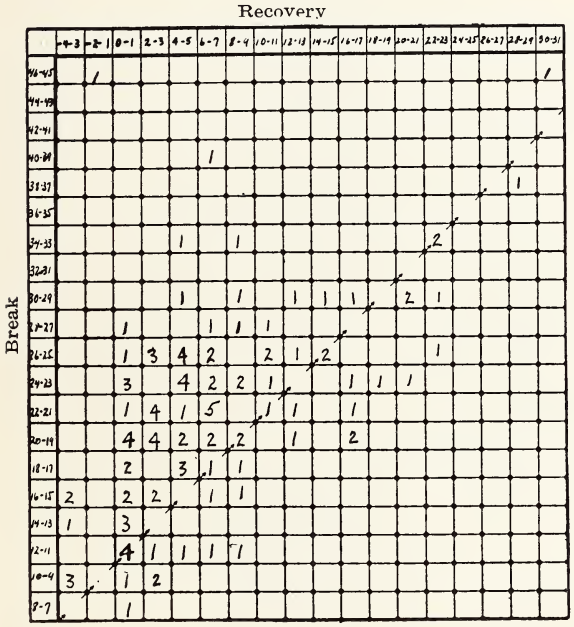
**Summary of Relationships Between Lateral Duction Findings (116 Cases)**

| Finding | r | P. E. of r |
|---|---|---|
| Base-out break: Far vs. near (10 and 16B)..... | .48 | .05 |
| Base-in break: Far vs. near (11 and 17B)..... | .46 | .05 |
| Base-out recovery: Far vs. near (10 and 16B)..... | .42 | .05 |
| Base-in recovery: Far vs. near (11 and 17B)..... | .31 | .06 |

Table IV is a summary of the relationships between lateral duction findings. The "two-way" distributions of these findings are presented in Scattergrams VI, VII, VIII, and IX.

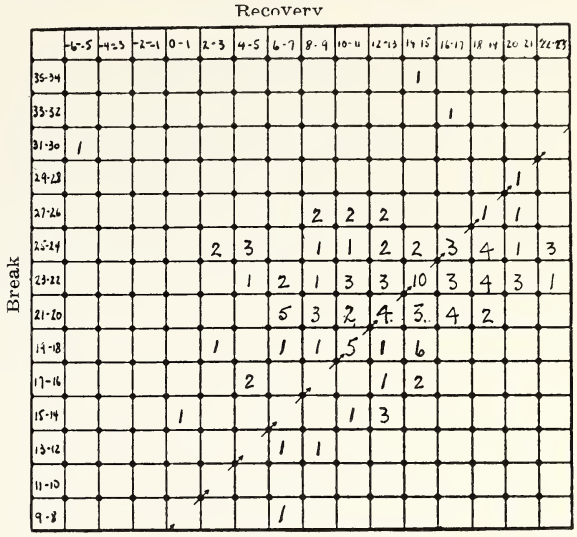
**Scattergram IV**

**Relationship Between Base-Out Break and Recovery Findings at 16 Inches (No. 16 B Finding for 116 Cases)**



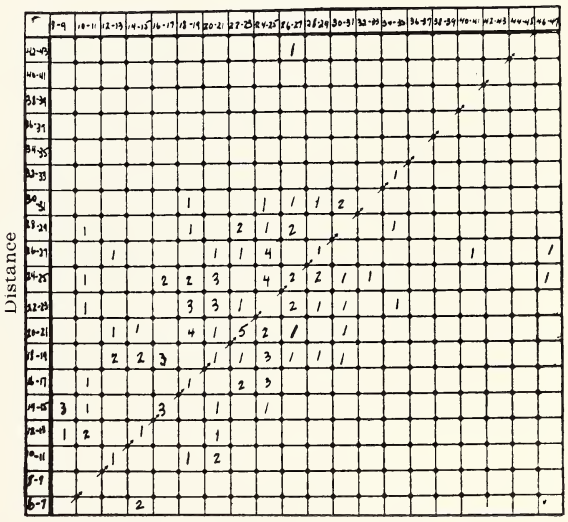

**Scattergram V**

**Relationship Between Base-In Break and Recovery Findings at 16 Inches (No. 17 B Finding for 116 Cases)**




**Scattergram VI**

**Relationship Between Base-Out Break Findings at Distance and Near (Nos. 10 and 16 B Findings for 116 Cases)**



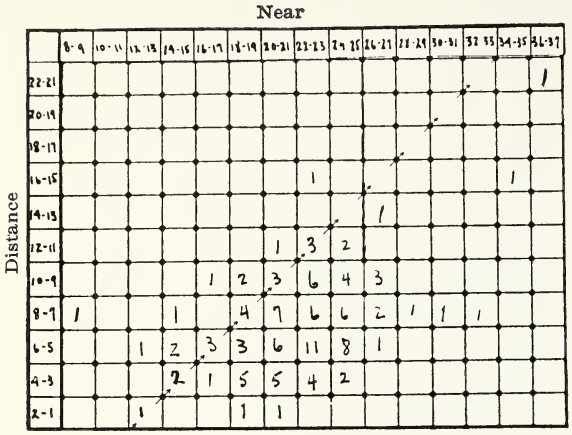

## Table V

**Summary of Vertical Duction Findings**

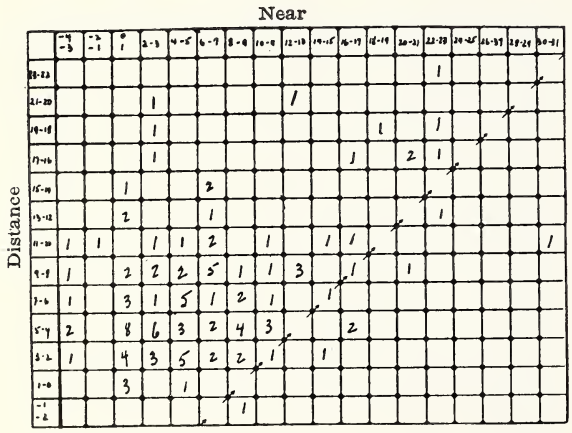
| Finding | Eye | Distance | f | Break M. | Break S.D. | Break S.E. of M. | Recovery M. | Recovery S.D. | Recovery S.E. of M. |
|---|---|---|---|---|---|---|---|---|---|
| Supra ..... | O.D. | 20′ | 112 | 2.78 | .84 | .08 | 1.17 | .43 | .04 |
| Infra ..... | O.D. | 20′ | 112 | 2.04 | .73 | .07 | .94 | .42 | .04 |
| Supra ..... | O.S. | 20′ | 112 | 2.55 | .82 | .08 | 1.20 | .47 | .04 |
| Infra ..... | O.S. | 20′ | 112 | 2.15 | .91 | .09 | .98 | .48 | .05 |
| Supra ..... | O.D. | 16″ | 113 | 3.37 | 1.47 | .14 | 1.62 | .87 | .08 |
| Infra ..... | O.D. | 16″ | 113 | 2.70 | 1.53 | .14 | 1.31 | .94 | .79 |
| Supra ..... | O.S. | 16″ | 113 | 3.21 | 1.58 | .15 | 1.66 | .93 | .09 |
| Infra ..... | O.S. | 16″ | 113 | 2.52 | 1.58 | .15 | 1.21 | .76 | .07 |

Table V is a summary of the vertical duction findings. Following Table V, a series of scattergrams is used to show graphically the relationships between findings.

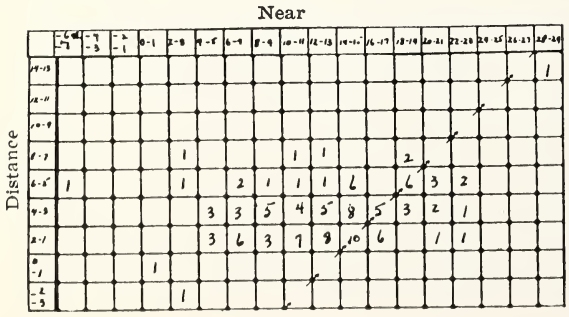
**Scattergram VII**
**Relationship Between Base-In Break Findings at Distance and Near (Nos. 11 and 17 B Findings for 116 Cases)**




**Scattergram VIII**
**Relationship Between Base-Out Recovery Findings at Distance and Near (Nos. 10 and 16 B Findings for 116 Cases)**




**Scattergram IX**
**Relationship Between Base-In Recovery Findings at Distance and Near (Nos. 11 and 17 B Findings for 116 Cases)**




The distributions of the vertical duction findings at *distance*, in terms of break and recovery, are reported in four scattergrams: Scattergram X, right supraduction Scattergram XI, right infraduction; Scattergram XII, left supraduction; and Scattergram XIII, left infraduction.

**Scattergram X**
**Summary of Right Supraduction Findings**

| Break \ Recovery: Prism Diopter | 0 | 0.5 | 1.0 | 1.5 | 2.0 | Total |
|---|---|---|---|---|---|---|
| 1.0 | 1 | .. | .. | .. | .. | 1 |
| 1.5 | 0 | 1 | 3 | .. | .. | 4 |
| 2.0 | 1 | 2 | 31 | .. | .. | 34 |
| 2.5 | .. | 0 | 5 | 6 | .. | 11 |
| 3.0 | .. | 1 | 27 | 2 | 14 | 44 |
| 3.5 | .. | .. | 0 | 1 | 0 | 1 |
| 4.0 | .. | .. | 9 | .. | 4 | 13 |
| 4.5 | .. | .. | 0 | .. | 0 | 0 |
| 5.0 | .. | .. | 2 | .. | 1 | 3 |
| 5.5 | .. | .. | 0 | .. | .. | 0 |
| 6.0 | .. | .. | 1 | .. | .. | 1 |
| Total | 2 | 4 | 78 | 9 | 19 | 112 |

**Scattergram XI**
**Summary of Right Infraduction Findings**

| Break \ Recovery: Prism Diopter | 0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | Total |
|---|---|---|---|---|---|---|---|---|
| 1.0 | .. | 12 | .. | .. | .. | .. | .. | 12 |
| 1.5 | .. | 7 | 16 | .. | .. | .. | .. | 23 |
| 2.0 | 3 | 5 | 45 | .. | .. | .. | .. | 53 |
| 2.5 | .. | 1 | 1 | .. | .. | .. | .. | 2 |
| 3.0 | .. | 1 | 11 | .. | 7 | .. | .. | 19 |
| 3.5 | .. | .. | 0 | .. | .. | .. | 1 | 1 |
| 4.0 | .. | .. | 1 | .. | .. | .. | .. | 1 |
| 4.5 | .. | .. | 0 | .. | .. | .. | .. | 0 |
| 5.0 | .. | .. | 0 | .. | .. | .. | .. | 0 |
| 5.5 | .. | .. | 0 | .. | .. | .. | .. | 0 |
| 6.0 | .. | .. | 1 | .. | .. | .. | .. | 1 |
| Total | 3 | 26 | 75 | 0 | 7 | 0 | 1 | 112 |

**Scattergram XII**
**Summary of Left Supraduction Findings**

| Break \ Recovery: Prism Diopter | 0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1.0 | .. | 1 | .. | .. | .. | .. | .. | .. | 1 |
| 1.5 | .. | 1 | 6 | .. | .. | .. | .. | .. | 7 |
| 2.0 | .. | 3 | 42 | 1 | .. | .. | .. | .. | 46 |
| 2.5 | .. | .. | 6 | 6 | 3 | .. | .. | .. | 15 |
| 3.0 | .. | .. | 21 | 1 | 11 | .. | .. | .. | 33 |
| 3.5 | .. | .. | 0 | .. | 0 | .. | .. | .. | 0 |
| 4.0 | 1 | .. | 1 | .. | 3 | .. | .. | .. | 5 |
| 4.5 | .. | .. | 0 | .. | 0 | .. | .. | 1 | 1 |
| 5.0 | .. | .. | 1 | .. | 2 | .. | .. | .. | 3 |
| 5.5 | .. | .. | 0 | .. | .. | .. | .. | .. | 0 |
| 6.0 | .. | .. | 1 | .. | .. | .. | .. | .. | 1 |
| Total | 1 | 5 | 78 | 8 | 19 | 0 | 0 | 1 | 112 |

**Scattergram XIII**

**Summary of Left Infraduction Findings**

Recovery

| Prism Diopter (Break) | —1.0 | —0.5 | 0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1.0 | .. | .. | 2 | 11 | .. | .. | .. | .. | 13 |
| 1.5 | .. | .. | .. | 9 | 14 | .. | .. | .. | 23 |
| 2.0 | .. | .. | .. | 4 | 41 | .. | .. | .. | 45 |
| 2.5 | .. | .. | .. | .. | 1 | 2 | .. | .. | 3 |
| 3.0 | .. | .. | .. | .. | 11 | 1 | 8 | 1 | 21 |
| 3.5 | .. | .. | .. | .. | 0 | .. | 0 | .. | 0 |
| 4.0 | .. | .. | .. | .. | 2 | .. | 1 | .. | 3 |
| 4.5 | .. | .. | .. | .. | 0 | .. | 0 | .. | 0 |
| 5.0 | 1 | .. | .. | .. | 1 | .. | 1 | .. | 3 |
| 5.5 | .. | .. | .. | .. | .. | .. | 0 | .. | 0 |
| 6.0 | .. | .. | .. | .. | .. | .. | 1 | .. | 1 |
| Total | 1 | 0 | 2 | 24 | 70 | 3 | 11 | 1 | 112 |

The distributions of the vertical duction findings at *near* point, in terms of break and recovery, are reported in Scattergrams XIV, XV, XVI, and XVII.

**Summary**

Caution should be exercised in the interpretation of these findings. While they may be fairly typical findings on a fifth-grade population, they can not be used as desirable expecteds. These findings were taken on one fifth-grade population (four classes) and by one examiner in one test situation.

1. From a functional point of view, a duction finding provides an index to fatigue rather than to the strength of a muscle, or a set of muscles.

**Scattergram XIV**

**Summary of Left Supraduction Findings**

Recovery

| Prism Diopter (Break) | —1.0 | —0.5 | 0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.5 | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 |
| 1.0 | .. | .. | .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 |
| 1.5 | .. | .. | .. | 0 | 2 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 2 |
| 2.0 | .. | .. | .. | 1 | 16 | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. | 18 |
| 2.5 | .. | .. | .. | 2 | 1 | 4 | 4 | .. | .. | .. | .. | .. | .. | .. | .. | 11 |
| 3.0 | .. | .. | 1 | .. | 11 | 1 | 33 | 3 | .. | .. | .. | .. | .. | .. | .. | 49 |
| 3.5 | .. | .. | 0 | .. | 0 | .. | 1 | 1 | .. | .. | .. | .. | .. | .. | .. | 2 |
| 4.0 | .. | .. | 0 | .. | 1 | .. | 6 | .. | 1 | .. | .. | .. | .. | .. | .. | 8 |
| 4.5 | .. | .. | 0 | .. | 0 | .. | 0 | .. | 0 | .. | .. | .. | .. | .. | .. | 0 |
| 5.0 | .. | .. | 0 | .. | 3 | .. | 2 | .. | 2 | .. | .. | .. | .. | .. | .. | 7 |
| 5.5 | .. | .. | 0 | .. | 0 | .. | 0 | .. | 0 | .. | .. | .. | .. | .. | .. | 0 |
| 6.0 | .. | .. | 1 | .. | 2 | .. | 2 | .. | 2 | .. | .. | .. | 1 | .. | .. | 8 |
| 6.5 | .. | .. | 0 | .. | 0 | .. | 0 | .. | .. | .. | .. | .. | .. | .. | .. | 0 |
| 7.0 | .. | .. | 1 | .. | 2 | .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. | 4 |
| 7.5 | .. | .. | .. | .. | 0 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0 |
| 8.0 | .. | .. | .. | .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | 2 |
| Total | 1 | 0 | 3 | 4 | 39 | 6 | 49 | 4 | 5 | 0 | 0 | 0 | 1 | 0 | 1 | 113 |

**Scattergram XV**

**Summary of Right Infraduction Findings**

Recovery

| Prism Diopter (Break) | 0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | .. | 8 | .. | .. | .. | .. | .. | .. | .. | .. | .. | 8 |
| 1.5 | .. | 5 | 17 | .. | .. | .. | .. | .. | .. | .. | .. | 22 |
| 2.0 | 2 | 1 | 30 | 3 | .. | .. | .. | .. | .. | .. | .. | 36 |
| 2.5 | 0 | .. | 1 | 2 | 4 | .. | .. | .. | .. | .. | .. | 7 |
| 3.0 | 0 | .. | 7 | 1 | 6 | .. | .. | .. | .. | .. | .. | 14 |
| 3.5 | 0 | .. | 0 | .. | 0 | .. | 1 | .. | .. | .. | .. | 1 |
| 4.0 | 0 | .. | 4 | .. | 5 | .. | 1 | .. | .. | .. | .. | 10 |
| 4.5 | 0 | .. | 0 | .. | 0 | .. | 0 | .. | .. | .. | .. | 0 |
| 5.0 | 0 | .. | 0 | .. | 4 | .. | 1 | .. | .. | .. | .. | 5 |
| 5.5 | 0 | .. | 0 | .. | 0 | .. | 0 | .. | .. | 1 | 1 | 2 |
| 6.0 | 1 | .. | 2 | .. | 1 | .. | 1 | .. | .. | .. | 0 | 5 |
| 6.5 | .. | .. | .. | .. | 0 | .. | .. | .. | .. | .. | 0 | 0 |
| 7.0 | .. | .. | .. | .. | 1 | .. | .. | .. | .. | .. | 0 | 1 |
| 7.5 | .. | .. | .. | .. | 0 | .. | .. | .. | .. | .. | 0 | 0 |
| 8.0 | .. | .. | .. | .. | 1 | .. | .. | .. | .. | .. | 1 | 2 |
| Total | 3 | 14 | 61 | 6 | 22 | 0 | 4 | 0 | 0 | 1 | 2 | 113 |

**Scattergram XVI**

**Summary of Left Supraduction Findings**

| Prism Diopter (Break) | Recovery 0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 |
| 1.5 | .. | 2 | 3 | .. | .. | .. | .. | .. | .. | .. | .. | .. | 5 |
| 2.0 | .. | .. | 33 | 2 | .. | .. | .. | .. | .. | .. | .. | .. | 35 |
| 2.5 | .. | .. | 1 | 5 | 3 | .. | .. | .. | .. | .. | .. | .. | 9 |
| 3.0 | .. | .. | 7 | 1 | 23 | 2 | .. | .. | .. | .. | .. | .. | 33 |
| 3.5 | .. | .. | 0 | .. | 0 | .. | 1 | .. | .. | .. | .. | .. | 1 |
| 4.0 | .. | .. | 2 | .. | 3 | .. | 3 | .. | .. | .. | .. | .. | 8 |
| 4.5 | .. | .. | 0 | .. | 0 | .. | 0 | .. | .. | .. | .. | .. | 0 |
| 5.0 | .. | .. | 1 | .. | 4 | .. | 3 | .. | 1 | .. | .. | .. | 9 |
| 5.5 | .. | .. | 0 | .. | 0 | .. | 0 | .. | 0 | .. | .. | .. | 0 |
| 6.0 | 2 | .. | 1 | .. | 1 | .. | 0 | .. | 1 | 1 | .. | 1 | 7 |
| 6.5 | .. | .. | 0 | .. | 0 | .. | 0 | .. | .. | .. | .. | .. | 0 |
| 7.0 | .. | .. | 1 | .. | 0 | .. | 0 | .. | .. | .. | .. | .. | 1 |
| 7.5 | .. | .. | .. | .. | 0 | .. | 0 | .. | .. | .. | .. | .. | 0 |
| 8.0 | .. | .. | .. | .. | 0 | .. | 2 | .. | .. | .. | 1 | .. | 3 |
| 8.5 | .. | .. | .. | .. | 0 | .. | .. | .. | .. | .. | .. | .. | 0 |
| 9.0 | .. | .. | .. | .. | 1 | .. | .. | .. | .. | .. | .. | .. | 1 |
| Total | 2 | 3 | 49 | 8 | 35 | 2 | 9 | 0 | 2 | 1 | 1 | 1 | 113 |

**Scattergram XVII**

**Summary of Left Infraduction Findings**

| Prism Diopter (Break) | Recovery 0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.5 | 1 | . | . | . | . | . | . | . | . | . | 1 |
| 1.0 | 1 | 16 | . | . | . | . | . | . | . | . | 17 |
| 1.5 | 1 | 4 | 11 | . | . | . | . | . | . | . | 16 |
| 2.0 | 0 | 1 | 38 | 2 | . | . | . | . | . | . | 41 |
| 2.5 | 0 | . | 1 | 0 | 4 | . | . | . | . | . | 5 |
| 3.0 | 0 | . | 2 | 1 | 8 | 1 | . | . | . | . | 12 |
| 3.5 | 0 | . | 0 | . | 0 | . | . | . | . | . | 0 |
| 4.0 | 0 | . | 0 | . | 5 | . | 2 | . | . | . | 7 |
| 4.5 | 0 | . | 0 | . | 0 | . | 0 | . | . | . | 0 |
| 5.0 | 1 | . | 1 | . | 2 | . | 1 | . | . | . | 5 |
| 5.5 | 0 | . | 0 | . | 0 | . | 0 | . | . | . | 0 |
| 6.0 | 1 | . | 2 | . | 1 | . | 1 | . | 1 | . | 6 |
| 6.5 | . | . | . | . | 0 | . | . | . | 0 | . | 0 |
| 7.0 | . | . | . | . | 0 | . | . | . | 0 | . | 0 |
| 7.5 | . | . | . | . | 0 | . | . | . | 0 | . | 0 |
| 8.0 | . | . | . | . | 2 | . | . | . | 1 | . | 3 |
| Total | 5 | 21 | 55 | 3 | 22 | 1 | 4 | 0 | 2 | 0 | 113 |

2. Since, in one sense, a duction finding provides an index to the degree of interference in the binocular functions, it is considered to be a *symptom*. Symptoms are important considerations in the identification of a syndrome, but they are not treated as *causes*. In view of this, the reconditioning is not primarily a "building of duction" procedure.
3. In general, there appears to be considerable agreement regarding the need for visual re-education as well as for lens correction.
4. From these data, there appears to be a real need for taking *both* far-point and near-point duction findings.
5. In general, the supraduction findings tended to be higher than the infraduction findings.
6. It was possible to secure blur findings at near on approximately one-half of the cases.
7. The means of the lateral duction breaks approximated "expecteds," but the means of recoveries were lower than those "expected." This obtained for both near and far findings.
8. The relationships between break and recovery findings were positive but fairly low. The Pearson Product Moment r's ranged from .25 to .56.
9. The relationships between far point and near point lateral duction findings were positive. The Pearson Product Moment r's ranged from .31 to .48.
10. The means for the vertical duction break findings ranged from 2.04 to 3.37; for the recovery findings, from .94 to 1.66.

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# Part XVII

## Phorias

The study of phorias—both lateral and vertical—has intrigued refractionists, psychologists, and educators. Very often educators and school psychologists have been discouraged with their findings on the relationship between phoria findings and visual readiness for reading (5, p. 3). This has been true for a number of reasons of which two will be mentioned here. First, the whole problem of *visual* readiness for near-point activities has been clouded by confusions regarding the label "visual readiness." The relationship of *visual* readiness to *reading* readiness has not been clearly thought through. Second, phoria findings have been treated as entities. Sound scholarship and research would have precluded this last possibility of error. Some of this confusion, however, appears to have resulted from out-moded or erroneous concepts of a phoria.

Some of the confused thinking regarding phorias appears to have semantic implications. Orthophoria, like emmetropia, is infrequently found. In part, the incidence of orthophoria depends upon how it is defined. The connotations and denotations of a given label, or term, tend to direct thinking and practice. The use of the term *convergence insufficiency* is indicative of thinking in one direction, while the use of the term *adductive fatigue* is indicative of thinking in another direction. Thus, it is difficult to revise thinking without the use of a new set of labels.

A phoria is an indicator, a symptomatic finding. What a phoria *indicates* for a given practitioner depends upon the approach being made. Those making a mechanistic approach are likely to conceive of a phoria as an entity; that is, they are likely to interpret a phoria without considering the relationship of this finding to other findings in the analysis procedure. This group is concerned with prism exercises, convergence insufficiency, muscle strength, and the like. On the other hand, those making a psycho-physiological approach to the analysis of seeing problems emphasize *relationships* between findings for the purpose of identifying syndromes of interference in the binocular functions.

Duke-Elder (10) defines exophoria as "the condition wherein the visual axes tend to deviate outwards, is the most common anomaly of the muscle balance, for, as we have seen, the position of rest is most usually of slight divergence." Skeffington (8), making a psycho-physiological approach, defines exophoria as "the area of compensation (delayed redintegration) between triangulation and focus reflexes, learned to protect the mechanism of triangulation (convergence) against changes taking place between reflexes." Skeffington's position is strengthened by Dr. Walter B. Lancaster (13) who attacks "the widespread erroneous idea that in most cases heterophoria is due to *weakness* of one or more of the extra-ocular muscles."

Some question has been raised regarding the need for taking both habitual and induced phorias. This has been explained as follows (8, p. 4):

"If the power found in the Subjective increases the exophoria *at either far or near*, it is taking a long chance to prescribe it. The phoria measures *in the Convergence*, what the Subjective and the "net-at-near" measures *in the Accommodation.*

*"The phoria tells just how much Accommodation may be changed with a lens, without making trouble in the Convergence."*

Maxwell states the case as follows (14, p. 334):

> "In some cases it is advisable to make heterophoria and duction tests without lenses, with the patient's former prescription in place, and with the new correction. By so doing, the effect of lenses on the ocular muscle balance is ascertained. Esophoria at distance, caused by accommodative action from uncorrected hyperopia or overcorrected myopia, may disappear under the influence of proper lenses."

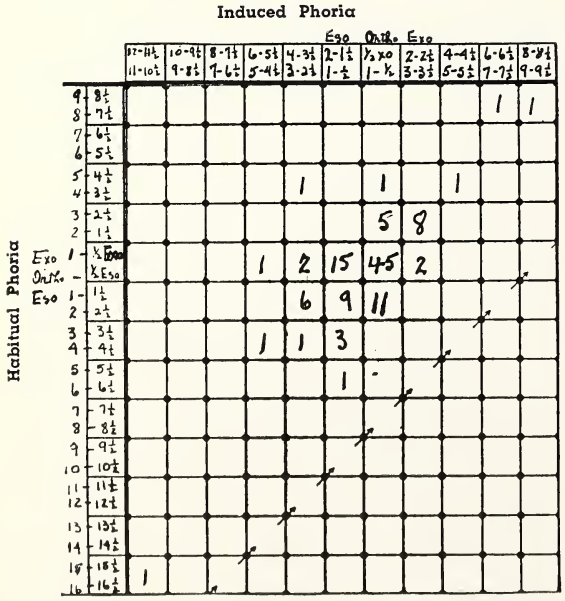
Tests of lateral imbalance have been described and summarized by Betts (5, p. 4). Those in common use are dissociation tests. Instruments,

techniques, and procedures used for the analysis of seeing difficulties are in need of careful and considered reappraisal by those making a psychophysiological approach. For example, Dr. George Crow has made informal statements regarding the desirability of studying phorias without the use of dissociation techniques. When taking near and far fixation findings, the examiner can ask the subject if he sees two lights at near point when fixation is at distance. If two are seen, then he should be further questioned to ascertain whether or not the two lights are on the same horizontal plane. More experimental work is needed on analysis routines.

For this study, six lateral phoria findings were taken by the refractionist. Habitual phoria findings were taken at distance (20 feet) and at near (16 inches). Phorias induced by the manifest, or basic formula, were taken at distance and at near. A fifth phoria was taken through the dissociated cross cylinder finding. The sixth phoria was taken through the fused cross cylinder finding. In addition to these findings taken by the refractionist, two lateral balance findings were taken by means of Slide DB-9 of the Betts Ready to Read battery.

Two vertical balance findings (distance and near) were taken by the refractionist. Both of these findings were taken through the manifest, or basic formula. In addition, near-point and far-point vertical balance findings were taken by means of Slide DB-8 of the Betts Ready to Read battery.

**Scattergram I**
**Relationship Between Habitual Phoria and Induced Phoria Findings at Distance (Nos. 3 and 8 Findings for 116 Cases)**



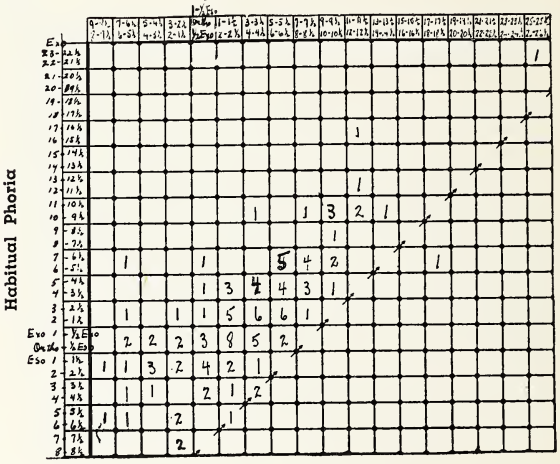

**Findings**

Relationships between lateral phoria findings are summarized in Table I. Scattergrams I to VII, inclusive, are used to show graphically these relationships. Data on lateral phoria findings are summarized in Table II.

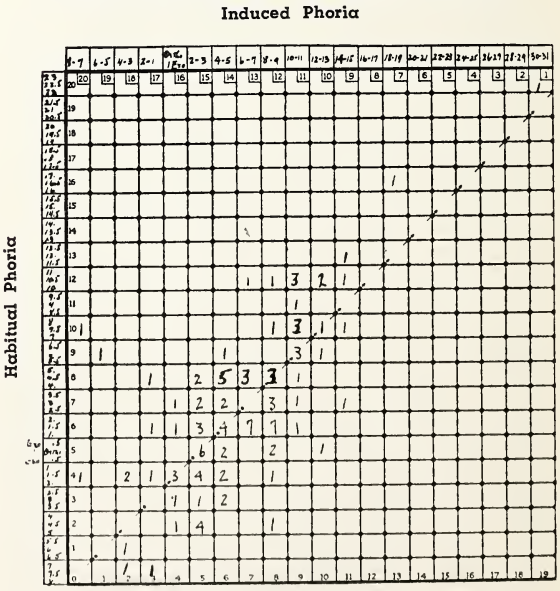
**Table I**
**Summary of Relationships Between Lateral Phoria Findings**

| Finding | Distance | f | r | P. E. of r |
|---|---|---|---|---|
| 3 and 8 | 20′ | 116 | .65 | .036 |
| 13A and 13B | 16″ | 115 | .76 | .025 |
| 13A and 15A | 16″ | 113 | .66 | .036 |
| 13A and 15B | 16″ | 113 | .77 | .026 |
| 15A and 15B | 16″ | 115 | .80 | .023 |
| 3 and 13A | 20′ and 16″ | 115 | .39 | .053 |
| 8 and 13B | 20′ and 16″ | 116 | .46 | .031 |

**Scattergram II**
**Relationship Between Habitual Phoria and Induced (Through Manifest) Phoria Findings at Near (Nos. 13A and 13B Findings for 115 Cases)**

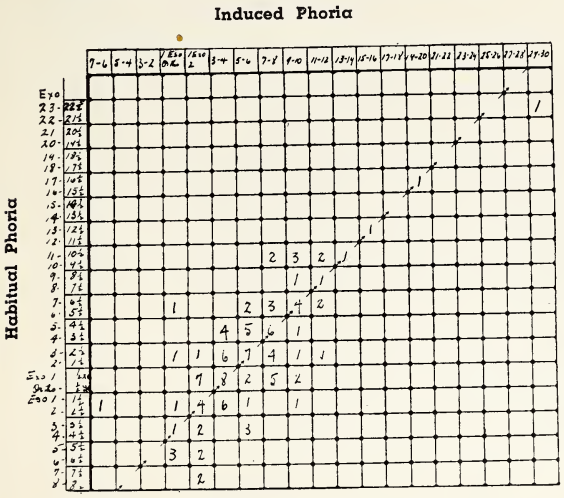



**Scattergram III**
**Relationship Between Habitual Phoria and Induced (Through Dissociated Cross Cylinder Finding) Phoria Findings at Near (Nos. 13A and 15A Findings for 113 Cases)**



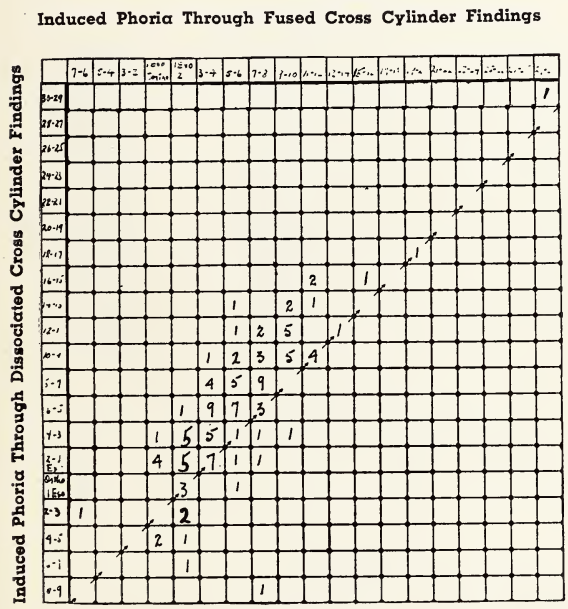
## Scattergram IV

**Relationship Between Habitual Phoria and Induced (Through Fused Cross Cylinder Findings) Phoria Findings at Near (Nos. 13A and 15B Findings for 113 Cases)**



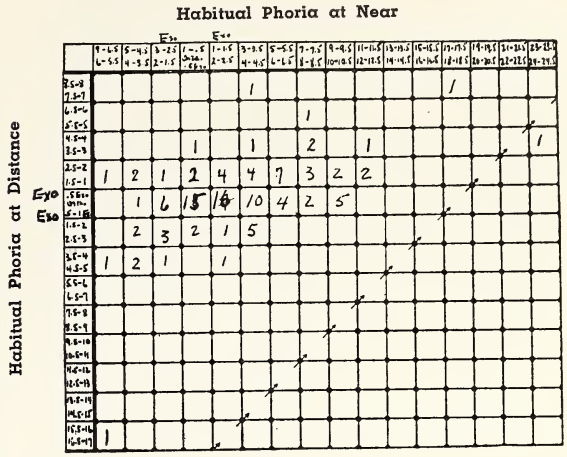

## Scattergram V

**Relationship Between Induced Phoria Findings at Near (Nos. 15A and 15B Findings for 115 Cases)**



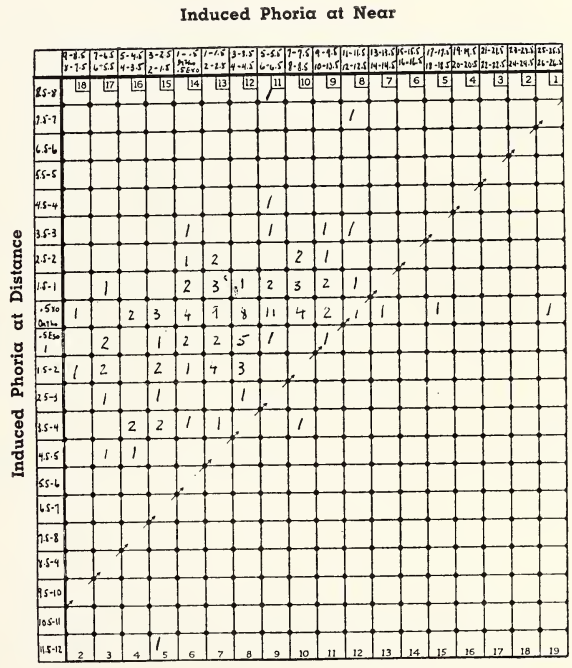

## Scattergram VI

**Relationship Between Habitual Phoria Findings at Distance and at Near (Nos. 3 and 13A Findings for 115 Cases)**




## Scattergram VII

**Relationship Between Induced (Through Manifest) Phoria Findings at Distance and at Near**




## Table II

**Summary of Data on Lateral Phorias**

| | Distance | f | M. | S.D. | S.E. of M. |
|---|---|---|---|---|---|
| Habitual (No. 3)..... | 20′ | 116 | .09 Exo. | 2.6 | .24 |
| Induced through manifest (No. 8)..... | 20′ | 117 | .19 Eso. | 2.3 | .21 |
| Habitual (No. 13A).... | 16″ | 115 | 2.48 Exo. | 4.8 | .44 |
| Induced through manifest (No. 13B)..... | 16″ | 116 | 2.81 Exo. | 1.7 | .16 |
| Induced through dissociated cross cylinder (No. 15A) ..... | 16″ | 115 | 5.84 Exo. | 5.3 | .49 |
| Induced through fused cross cylinder (No. 15B) ..... | 16″ | 115 | 5.66 Exo. | 4.4 | .41 |

Table III shows the distribution of the habitual lateral phoria findings and the induced lateral phoria findings at distance and at near point. At far point, the mean reading for habitual phorias was 0.09 ± 2.57 exophoria; for induced phorias, 0.19 ± 2.27 esophoria. At near point, the mean habitual phoria reading was 2.48 ± 4.75 exophoria; for induced phorias, 2.81 ± 1.71 exophoria.

**Table III**

**Summary of Findings of Habitual and Induced Phorias**

| | Diopters | Habitual 20 ft. No. 3 | Habitual 16 in. No. 13A | Induced 20 ft. No. 3 | Induced 16 in. No. 13B |
|---|---|---|---|---|---|
| Exo. | 26.0–26.5 | .. | .. | .. | 1 |
| | 25.0–25.5 | .. | .. | .. | 0 |
| | 24.0–24.5 | .. | .. | .. | 0 |
| | 23.0–23.5 | .. | 1 | .. | 0 |
| | 22.0–22.5 | .. | 0 | .. | 0 |
| | 21.0–21.5 | .. | 0 | .. | 0 |
| | 20.0–20.5 | .. | 0 | .. | 0 |
| | 19.0–19.5 | .. | 0 | .. | 0 |
| | 18.0–18.5 | .. | 0 | .. | 1 |
| | 17.0–17.5 | .. | 1 | .. | 0 |
| | 16.0–16.5 | .. | 0 | .. | 0 |
| | 15.0–15.5 | .. | 0 | .. | 0 |
| | 14.0–14.5 | .. | 0 | .. | 1 |
| | 13.0–13.5 | .. | 0 | .. | 0 |
| | 12.0–12.5 | .. | 1 | .. | 2 |
| | 11.0–11.5 | .. | 2 | .. | 2 |
| | 10.0–10.5 | .. | 6 | .. | 4 |
| | 9.0– 9.5 | .. | 1 | .. | 3 |
| | 8.0– 8.5 | 2 | 1 | 1 | 4 |
| | 7.0– 7.5 | 0 | 7 | 1 | 5 |
| | 6.0– 6.5 | 0 | 6 | 0 | 7 |
| | 5.0– 5.5 | 1 | 5 | 0 | 10 |
| | 4.0– 4.5 | 2 | 11 | 1 | 9 |
| | 3.0– 3.5 | 5 | 10 | 4 | 10 |
| | 2.0– 2.5 | 8 | 10 | 6 | 12 |
| | 1.0– 1.5 | 20 | 14 | 15 | 9 |
| | Ortho– 0.5 | 42 | 10 | 49 | 7 |
| Eso. | 0.5– 1.0 | 17 | 9 | 15 | 5 |
| | 1.5– 2.0 | 12 | 6 | 12 | 4 |
| | 2.5– 3.0 | 1 | 4 | 3 | 5 |
| | 3.5– 4.0 | 5 | 3 | 7 | 1 |
| | 4.5– 5.0 | 1 | 4 | 2 | 4 |
| | 5.5– 6.0 | 0 | 1 | 0 | 6 |
| | 6.5– 7.0 | 0 | 2 | 0 | 1 |
| | 7.5– 8.0 | 0 | 0 | 0 | 1 |
| | 8.5– 9.0 | 0 | 0 | 0 | 1 |
| | 9.5–10.0 | 0 | 0 | 0 | 0 |
| | 10.5–11.0 | 0 | 0 | 0 | 0 |
| | 11.5–12.0 | 0 | 0 | 1 | 0 |
| | 12.5–13.0 | 0 | 0 | 0 | 0 |
| | 13.5–14.0 | 0 | 0 | 0 | 0 |
| | 14.5–15.0 | 0 | 0 | 0 | 0 |
| | 15.5–16.0 | 1 | 0 | 0 | 0 |
| | Total | 116 | 115 | 117 | 116 |
| | M | 0.09 | 2.48 | 0.19 | 2.81 |
| | S.D. | ± 2.57 | ± 4.75 | ± 2.27 | ± 1.71 |
| | S.E. of M | ± 0.24 | ± 0.44 | ± 0.21 | ± 0.16 |

A tropia is the observable deviation of one eye. The observations of this condition are summarized in Table IV.

**Table IV**

**Summary of Tropias**

| Condition | f | % |
|---|---|---|
| Exotropia | | |
| Right Eye | 0 | 0.0 |
| Left Eye | 1 | 0.8 |
| Esotropia | | |
| Right Eye | 0 | 0.0 |
| Left Eye | 1 | 0.8 |
| Normal | 120 | 98.4 |
| Total | 122 | 100.0 |

The distribution of the vertical phoria findings at distance and at near point are shown in Table V. It will be noted that 93.04 per cent of the subjects were orthophoric at distance and 90.5 per cent were orthophoric at near point. LH is left hyperphoria; RH is right hyperphoria.

Data on cases with hyperphoria findings are presented in Table VI. These data are summarized in Table VII.

## Summary

1. By means of the Pearson Product Moment formula used for studying the relationships between findings, r's were found to range from .39 to .80 for the lateral phoria findings.
2. The findings of this study indicate quite clearly the need for taking both near point and far point readings.
3. Less than two per cent of this population exhibited heterotropia.

**Table V**

**Summary of Vertical Phoria Findings**

| Prism Diopter | 20 ft. f | 16 in. f |
|---|---|---|
| 5 LH | .. | 1 |
| 4.5 LH | .. | 0 |
| 4.0 LH | .. | 0 |
| 3.5 LH | .. | 0 |
| 3.0 LH | .. | 1 |
| 2.5 LH | .. | 0 |
| 2.0 LH | 1 | 0 |
| 1.5 LH | 0 | 0 |
| 1.0 LH | 2 | 0 |
| 0.5 LH | 1 | 7 |
| Orthophoria | 107 | 105 |
| 0.5 RH | 4 | 1 |
| 1.0 RH | 0 | 0 |
| 1.5 RH | 0 | 1 |
| Total | 115 | 116 |
| M | 0.0217 | 0.0043 |
| S.D. | ± 0.25 | ± 0.57 |
| S.E. of M | ± 0.023 | ± 0.053 |

**Table VI**

**Data on Cases with Hyperphoria**

| Case No. | Distance | Near |
|---|---|---|
| 1 | ½ L.H. | Ortho |
| 10 | Ortho | ½ R.H. |
| 16 | 1 L.H. | Ortho |
| 18 | Ortho | ½ L.H. |
| 20 | Ortho | ½ L.H. |
| 22 | Ortho | 3 L.H. |
| 29 | Ortho | ½ L.H. |
| 32 | 1 L.H. | Ortho |
| 56 | ½ R.H. | Ortho |
| 68 | Ortho | ½ L.H. |
| 81 | Ortho | ½ L.H. |
| 86 | Ortho | ½ L.H. |
| 91 | ½ R.H. | Ortho |
| 97 | Ortho | ½ L.H. |
| 98 | Ortho | 1½ R.H. |
| 99 | ½ R.H. | Ortho |
| 102 | ½ R.H. | Ortho |
| 119 | 2 L.H. | 5 L.H. |

**Table VII**

**Summary of Hyperphoria Data**

| | f | % |
|---|---|---|
| Both Near and Distance | 1 | 5.6 |
| Near only | 10 | 55.6 |
| Distance only | 7 | 38.8 |
| Total | 18 | 100.0 |

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# Part XVIII

## Amplitude of Accommodation

Amplitude of accommodation is one of a series of findings that can be taken as part of a *screening* routine as well as a part of an *analysis* routine. For screening purposes (i.e., to detect for referral to a specialist), Prince's rule or some modification of it has been found to be satisfactory for determining near point of accommodation, or punctum proximum. For the analysis of a seeing difficulty, amplitude of accommodation is measured (for O.D., O.S., O.U.) by means of minus spheres in a refactor.

Dvorine comments briefly on ways of measuring amplitude of accommodation ([9]p. 32):

> "There are three ways of measuring the amplitude of accommodation. First, the push-up or approach-to-blur method; second, the test with minus lenses; third, a combination of the two methods. The objection to the first method is that the letters appear larger as they are brought closer to the patient. The objection to the minus lenses is that they apparently reduce the size of the letters. A technique combining the two methods has been evolved which is proving itself satisfactory."

Dvorine has given a brief description of the procedure used in this study for taking the amplitude of accommodation finding ([9]p. 32):

> "While wearing the subjective formula, the patient is instructed to fix a line of print, or better still, a group of numbers of a size equivalent to the 60% line on the reduced Snellen chart. The test chart is advanced to the 13 inch mark on the phoropter rod, and if the letters or numbers can be discerned by the patient, minus lenses are added monocularly, at first, to find the amplitude for each eye. A slight blurring of the letters is the signal to stop. The test is repeated binocularly and the amplitude is recorded as the sum of the minus lenses introduced into the phoropter plus 2.50 diopters allowed for the distance, instead of the usual 3.00 diopters."

Punctum proximum is the near point of accommodation. It is the point nearest to the eye at which a target is not blurred. "The furthest distance away at which an object can be seen clearly is called the *far point (punctum remotum)*" ([3]p. 140).

Maxwell defines amplitude of accommodation as follows ([12]p. 55):

> "*Amplitude of Accommodation* is the difference between the refractive power of the lens (measured in diopters) in a relaxed condition, and when accommodation is maximum. This must be distinguished from the *range of accommodation*, which is the linear distance between the far-point and the near-point."

Skeffington ([1]p. 2 of Lecture 2) points out that amplitude of accommodation is one of five categories of findings in a visual analysis routine: "Amplitude of Accommodation, wherein we determine the effect that advancing senility has had on the relationship between the two patterns."

In the visual analysis routine used in this study, the amplitude of accommodation was taken, at least in part, for the purpose of determining lag of accommodation ([5]p. 2):

> "It is evident that as the Amplitude of Accommodation *lowers*, the relationship between convergence and accommodation will change, and so the LAG of accommodation, which is figured from the exophoria, will change."

Regarding lag of accommodation, Atkinson states ([2]pp. 49-50):

> "Many authorities, headed by Sheard, hold that even in attentive near vision the accommodation normally lags behind the convergence; that is to say, while the internal recti make the eyes accurately focus a point, let us say, 33 cm. distant, with 3 meter angles of convergence, the ciliaries do not accurately focus that point with 3 D. of accommodation, but exercise anywhere from .50 D. to .75 D. less than this quantity. And this is technically known as the 'accommodative lag.'
>
> "Other authorities, admitting the discrepancy between accommodation and convergence at a given near point, hold that it is only an apparent discrepancy, due to the different refrangibility of the color waves in the entering and emerging light, and that it disappears when a single pure color is employed in the measurement."

From a number of specialists' reports on file in The Reading Clinic, it is clear that amplitude of accommodation is not taken on all cases, even serious reading disability cases. There may be several explanations of this situation. From the data in our files, it appears that only one analysis routine is set up to show the relationships between findings. The emphasis, although not exclusively so, in this routine is on the psycho-physiological approach. It appears, then, that those making a mechanistic approach to the study of seeing problems have been unable to demonstrate the need for this finding.

Zoethout ([14]p. 87), Dvorine ([9]p. 49), Berens ([8]p. 131), Maxwell ([12]pp. 55-56), and others have set up tables of expecteds based on Duane's findings. These findings were taken by the "push-up" method. This information is summarized in Table I.

**Table I**

**Expected Amplitude of Accommodation**

| Age | Near Point (Cm.) | Amplitude (Diopters) |
|---|---|---|
| 8 | .. | 13.8 ± 2.2 |
| 10 | 7 | 13.4 ± 2.2 |
| 15 | 8 | 12.3 ± 2.2 |
| 20 | 10 | 11.1 ± 2.2 |
| 25 | 12 | 9.9 ± 2.2 |
| 30 | 14 | 8.7 ± 2.2 |
| 35 | 18 | 7.3 ± 2.1 |
| 40 | 22 | 5.8 ± 2.1 |
| 45 | 28 | 3.6 ± 2.3 |
| 50 | 40 | 1.9 ± 1.1 |
| 55 | 51 | 1.3 ± .6 |
| 60 | 100 | 1.2 ± .5 |
| 65 | 200 | 1.0 ± .5 |
| 70 | 400 | .25 |

## Findings

The distribution of the findings for amplitude of accommodation (right eye, left eye, and binocular) are shown in Table II. These data were secured on the Huntingdon, Pa., cases.

**Table II**

**Summary of Findings on Amplitude of Accommodation**

| Diopter | Right Eye | Left Eye | Binocular |
|---|---|---|---|
| 16.25–16.50 | .. | 1 | .. |
| 15.75–16.00 | 1 | 1 | 1 |
| 15.25–15.50 | 3 | 1 | 0 |
| 14.75–15.00 | 8 | 6 | 1 |
| 14.25–14.50 | 10 | 9 | 2 |
| 13.75–14.00 | 9 | 8 | 4 |
| 13.25–13.50 | 8 | 10 | 2 |
| 12.75–13.00 | 9 | 14 | 2 |
| 12.25–12.50 | 6 | 8 | 2 |
| 11.75–12.00 | 11 | 7 | 2 |
| 11.25–11.50 | 9 | 6 | 3 |
| 10.75–11.00 | 5 | 6 | 4 |
| 10.25–10.50 | 9 | 7 | 3 |
| 9.75–10.00 | 7 | 7 | 5 |
| 9.25– 9.50 | 5 | 7 | 8 |
| 8.75– 9.00 | 0 | 1 | 7 |
| 8.25– 8.50 | 3 | 4 | 6 |
| 7.75– 8.00 | 3 | 4 | 8 |
| 7.25– 7.50 | 0 | 1 | 12 |
| 6.75– 7.00 | 1 | 2 | 5 |
| 6.25– 6.50 | 2 | 3 | 8 |
| 5.75– 6.00 | 3 | 1 | 8 |
| 5.25– 5.50 | 1 | 1 | 14 |
| 4.75– 5.00 | 1 | 0 | 4 |
| 4.25– 4.50 | 1 | 1 | 2 |
| 3.75– 4.00 | 1 | 0 | 1 |
| 3.25– 3.50 | 0 | 0 | 1 |
| Total | 116 | 116 | 115 |
| M. | 11.69 | 11.66 | 8.37 |
| S.D. | ± 2.67 | ± 2.64 | ± 2.76 |
| S.E. of M. | ± 0.25 | ± 0.24 | ± 0.26 |

## Summary

1. There is a wide range in amplitude of accommodation for children of a given age. For this study the amplitude (O.U.) ranged from 3.25 to 15.75 diopters.

2. The binocular findings tended to be lower than the monocular findings. This was an interesting fiinding in view of the fact that Maxwell ([12]p. 56) states that "Binocular accommodation is usually greater."

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# Part XIX

## Relative Accommodation at Near Point

Two sets of findings taken for this study have interesting psycho-physiological implications. Base-out prism to blur and base-in prism to blur (at sixteen inches) provide an index to how much convergence (triangulation) can be stimulated or inhibited without reflexly changing accommodation. Likewise, addition of minus sphere to blur and plus sphere to blur (at sixteen inches) provide an index to how much accommodation (focus) can be stimulated or inhibited without reflexly changing convergence. These two sets of findings are sometimes referred to as equilibrium findings.

Southall points out the implications of relative accommodation findings (13 p. 218):

> "When an emmetrope gazes with both eyes at a far distant object like a star, his accommodation cannot be lowered because it is already relaxed entirely. Since the image of a real object in a concave lens is nearer the lens than the object, the effect of placing concave glasses in front of a pair of emmetropic eyes will be to increase the accommodation; and yet provided the concave glasses are not too strong, the emmetrope can continue to fixate the star binocularly as long as the impulse for fusion is powerful enough to overcome the contrary motive of accommodation. The extent of independence of the two functions is determined by the strongest concave lenses that can be used without producing double vision of the distant object. In this way the *amplitude of relative accommodation,* as it is called, may be ascertained for the far point of an emmetropic eye.
>
> "On the other hand, when the object of binocular fixation is at the near point distance and therefore the maximum power of accommodation is being exerted in order to see the object distinctly, the situation is just the reverse of that described above, and now we have to ascertain the power of the strongest convex glasses that can be placed in front of the eyes without overcoming the effort of fusion. This will be the measure of the amplitude of relative accommodation at the near point."

Duane calls our attention to the relationship between accommodation and convergence (7 pp. 174-175):

> "Hence, through constant practice an intimate connection is effected between accommodation and convergence, so that with any given accommodation the corresponding effort of convergence is always made, and vice versa.
>
> "This connection, however, is not one that is rigid and insusceptible of change. On the contrary, we have the ability of emancipating ourselves from it within certain limits—that is, while in the act of converging for a certain distance, of making a little more or a little less accommodation than corresponds to this distance."

Duane continues (7 p. 175):

> ". . . we can bring stronger and stronger convex and concave glasses successively before the eye until finally we come to those with which distinct vision is no longer possible. We thus find the limits within which the accommodation may be augmented or relaxed, the convergence remaining the same (*relative accommodation*)."

In discussing the relationship between accommodation and convergence, Luedde points out the desirability of taking prism base-in and base-out blur points (3 p. 130):

> "The close and rather constant relation between accommodation and convergence may be disturbed also by placing prisms singly or in pairs, with bases in or out, before the eyes while they are converged upon an object at a given distance. In this way, possible variations in the degree of convergence can be estimated while accommodation remains unchanged. Prompt reactions of ciliary muscles to concave or convex lenses and of extra-ocular muscles to prisms indicate a dominant desire for sharp binocular single vision. These tests indicate that the clarity of retinal images automatically regulates the adjustment of accommodation and convergence. However, a degree of voluntary control for both functions is usually present and may be perfected by practice."

### Findings

The distribution of the findings on tolerance of accommodative stimulation are recorded in Table I.

**Table I**
**Summary of Findings on Tolerance of Accommodative Stimulation**
(Positive Relative Convergence)

| Diopter | f |
|---|---|
| 15.00-15.25 | 1 |
| 14.50-14.75 | 0 |
| 14.00-14.25 | 0 |
| 13.50-13.75 | 0 |
| 13.00-13.25 | 0 |
| 12.50-12.75 | 1 |
| 12.00-12.25 | 0 |
| 11.50–11.75 | 0 |
| 11.00-11.25 | 1 |
| 10.50-10.75 | 0 |
| 10.00-10.25 | 0 |
| 9.50- 9.75 | 0 |
| 9.00- 9.25 | 4 |
| 8.50- 8.75 | 1 |
| 8.00- 8.25 | 5 |
| 7.50- 7.75 | 4 |
| 7.00- 7.25 | 2 |
| 6.50- 6.75 | 3 |
| 6.00- 6.25 | 8 |
| 5.50- 5.75 | 8 |
| 5.00- 5.25 | 8 |
| 4.50- 4.75 | 9 |
| 4.00- 4.25 | 16 |
| 3.50- 3.75 | 11 |
| 3.00– 3.25 | 10 |
| 2.50- 2.75 | 10 |
| 2.00- 2.25 | 10 |
| 1.50- 1.75 | 2 |
| 1.00- 1.25 | 1 |
| Total | 115 |
| M. | 4.84 |
| S.D. | ± 2.34 |
| S.E. of M. | ± 0.22 |

The distribution of the findings on tolerance of accommodative inhibition are recorded in Table II.

**Table II**
**Summary of Findings of Tolerance of Accommodative Inhibition**
(Negative Relative Convergence)

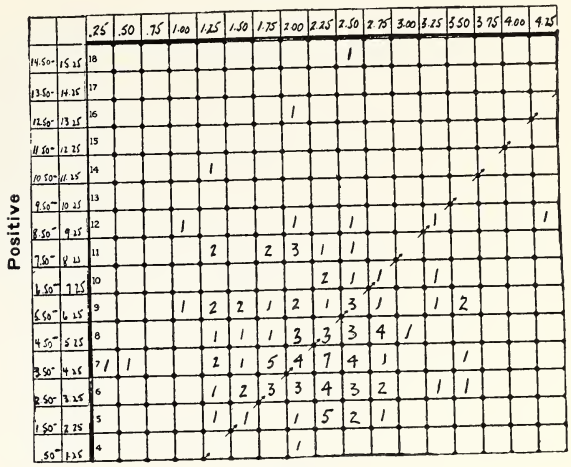
| Diopter | f |
|---|---|
| 4.25 | 1 |
| 4.00 | 0 |
| 3.75 | 0 |
| 3.50 | 4 |
| 3.25 | 4 |
| 3.00 | 1 |
| 2.75 | 10 |
| 2.50 | 19 |
| 2.25 | 23 |
| 2.00 | 19 |
| 1.75 | 12 |
| 1.50 | 7 |
| 1.25 | 10 |
| 1.00 | 2 |
| 0.75 | 0 |
| 0.50 | 1 |
| 0.25 | 1 |
| Total | 114 |
| M. | 2.16 |
| S.D. | ± 0.63 |
| S.E. of M. | ± 0.06 |

Scattergram I is presented to show the relationship between positive relative accommodation and negative relative accommodation findings. The Pearson Product Moment r was .02 ± .06, indicating very little relationship between the findings.

Atkinson points out the importance of relative accommodation findings. (2 p. 14):

> "The importance of ascertaining the patient's relative accommodation, positive and negative, lies in the fact that in conjunction with his relative convergence it represents the flexibility of these two functions. The nearer the relative accommodation approximates the normal, the more we can rely on the patient being able to maintain proper coordination between accommodation and convergence, and to find his own comfortable near-point when rendered emmetropic by proper correction."

**Scattergram I**
Relationship Between Positive Relative Accommodation and Negative Relative Accommodation Findings (114 Cases).




**Summary**

1. Relative accommodation findings provide an index to the relationship between accommodation and convergence.

2. The mean amount of accommodative stimulation tolerated by the cases used in this study was 4.8 D.

3. The mean amount of accommodative inhibition tolerated by the cases used in this study was 2.2 D.

4. In this study there appeared to be very little relationship between the relative accommodation findings.

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# Part XX

## Cycloplegic Findings

The chief purpose of this phase of the investigation was to study the relationship between cycloplegic and manifest findings. Considerable controversy has arisen over the use of "drops," but few, if any, data have been offered by the protagonists or the antagonists. Mydriatics (to dilate the pupil) and cycloplegics (to paralyze the ciliary muscle) are used for the investigation of pathology as well as for refraction. The controversy appears to be over the validity of the technique for refraction purposes.

May lists five uses of cycloplegics (6, p. 462):

> "Atropine (and homatropine) are used (1) in *iritis*, to dilate the pupil, prevent adhesions, and exert a sedative action; (2) in various diseases of the *cornea* and of the *deeper* structures; (3) after certain *operations;* (4) to paralyze accommodation in estimating the state of *refraction;* (5) to dilate the pupil for ophthalmoscopic examination."

If research findings on the psycho-physiology of seeing have a bearing on refraction, then it does not appear reasonable that the "accurate refraction" obtained from either manifest or cycloplegic readings can be used for the final prescription. All authorities on either refraction or the analysis of seeing difficulties appear to agree on the desirability of taking into account other readings which provide indexes to *binocular* functions. In short, neither manifest nor cycloplegic findings constitute an adequate appraisal of *seeing* functions. Cycloplegic findings for refractive purposes must be justified by those who make a mechanical approach.

For this study, a cycloplegic examination was made of every subject. It was done by instilling one drop of 5% homatropine solution into each eye, followed in ten minutes by one drop of Paredrine solution. One hour was allowed to elapse before the examination was begun. Findings similar to the retinoscopy and the subjective of the visual analysis were taken at twenty feet.

### Findings

The spherical findings on the cycloplegic examination are summarized in Table I. All distance sphere findings are summarized in Table II. Scattergrams I and II are presented to show graphically the relationships between manifest and cycloplegic findings. For the right eye findings, the Pearson Product Moment r was .88 ± .014; for the left eye, .85 ± .018.

**Table I**

**Summary of Spherical Findings of the Cycloplegic Examination**

| | Diopter | f |
|---|---|---|
| Plus | 8.25 | 1 |
| " | 8.00 | 0 |
| " | 7.75 | 0 |
| " | 7.50 | 1 |
| " | 7.25 | 0 |
| " | 7.00 | 0 |
| " | 6.75 | 0 |
| " | 6.50 | 0 |
| " | 6.25 | 0 |
| " | 6.00 | 1 |
| " | 5.25 | 0 |
| " | 5.50 | 0 |
| " | 5.25 | 1 |
| " | 5.00 | 1 |
| " | 4.75 | 1 |
| " | 4.50 | 0 |
| " | 4.25 | 0 |
| " | 4.00 | 1 |
| " | 3.75 | 1 |
| " | 3.50 | 1 |
| " | 3.25 | 1 |
| " | 3.00 | 2 |
| " | 2.75 | 4 |
| " | 2.50 | 4 |
| " | 2.25 | 8 |
| " | 2.00 | 10 |
| " | 1.75 | 14 |
| " | 1.50 | 19 |
| " | 1.25 | 27 |
| " | 1.00 | 47 |
| " | 0.75 | 34 |
| " | 0.50 | 24 |
| " | 0.25 | 1 |
| | Plano | 3 |
| Minus | 0.25 | 2 |
| " | 0.50 | 0 |
| " | 0.75 | 1 |
| " | 1.00 | 6 |
| " | 1.25 | 3 |
| " | 1.50 | 4 |
| " | 1.75 | 3 |
| " | 2.00 | 3 |
| " | 2.25 | 0 |
| " | 2.50 | 1 |
| " | * | |
| " | 4.75 | 1 |
| | Total | 230 |
| | M. | 1.10 |
| | S.D. | ± 1.37 |
| | S.E. of M. | ± 0.09 |

**Table II**

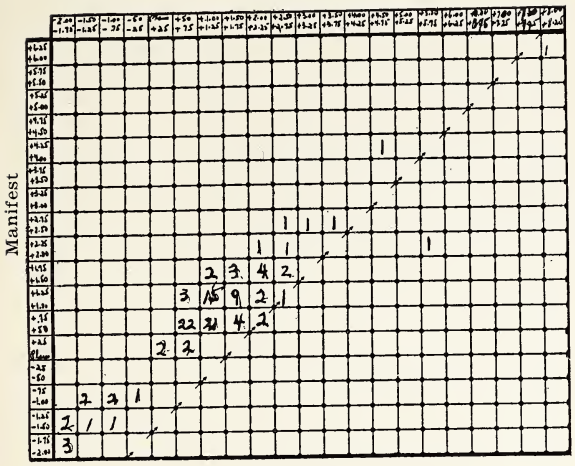
**Summary of Distance Sphere Findings**

| Finding | f | M. |
|---|---|---|
| Total Static Retinoscopic Findings | 118 | .70 |
| Total Manifest Findings | 118 | .47 |
| Total Cycloplegic Findings | 115 | 1.10 |
| Static Retinoscopic Plus Findings | 118 | .97 |
| Manifest Plus Findings | 118 | 1.05 |
| Cycloplegic Plus Findings | 115 | 1.39 |
| Static Retinoscopic Minus Findings | 118 | 1.21 |
| Manifest Minus Findings | 118 | 1.22 |
| Cycloplegic Minus Findings | 115 | 1.47 |

*No cases at these intervening class intervals.

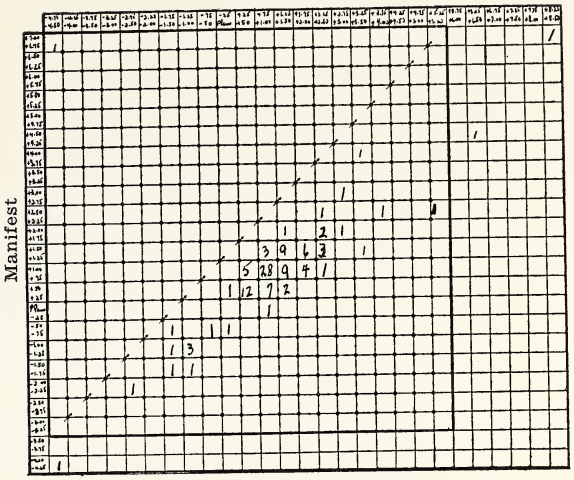
**Scattergram I**
**Relationship Between Manifest and Cycloplegic Findings (O. D. 114 Cases)**

Cycloplegic




**Scattergram II**
**Relationship Between Manifest and Cycloplegic Findings (O. S. 114 Cases)**

Cycloplegic




**Summary**

1. No additional intra-ocular pathology was detected during the cycloplegic examination.
2. No case accepted minus sphere on the manifest and plus sphere on the cycloplegic.
3. In general, there is a high relationship between manifest and cycloplegic findings.
4. The cycloplegic findings tended to be higher than the "static" retinoscope and the manifest findings.

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# Part XXI

## Incidence of Previous Corrections

One of the most challenging findings in this study was the percentage of the population that had received previous attention by a specialist. Only 25% of the children examined had ever been to a specialist. In addition, only 13% of the total population examined were wearing corrections when the study was initiated. Since this community was estimated to be at least average in terms of socio-economic status, this finding should stimulate further investigation of the extent to which school children have access to specialized services.

The qualitative era of education is just being ushered in. School administrators have been so busy with providing physical facilities that many other crucial needs have been defaulted.

Health services in public schools are notoriously inadequate. The establishment of much-needed coordinate services in schools will prove to be a long, slow evolutionary process. Teachers must be sensitized to both the educational and health implications of the findings in the health unit. On the other hand, the personnel of the health unit must be prepared to screen out and refer those cases needing the attention of a specialist. In addition, these health workers must acquire some understanding of the relationship between health and educational problems. This probably will require an unbiased investigation of the preparation of these workers. Until some of these steps are taken, education is likely to remain on a quantity rather than a quality basis.

With only 25% of the children in this community receiving the attention of one type of specialist, many more children in other communities are being denied the fruits of science. This presents a serious problem for those concerned with the developmental needs of children. Progressive and alert educators long have been concerned with the development of the "whole" individual. Perhaps this 25% represents a gain over conditions of twenty-five years ago, but it is clear that only a small beginning has been made.

From findings presented in this series of reports, it is evident that there is not only a need for research to improve visual analysis techniques, but also there is a very real need for making this improved service available to the general population. In view of the socio-economic status of this community, it cannot be said that the chief reason the parents failed to take their children to a specialist was a financial one. Education is probably a potent factor in this situation.

The problem presented by these findings is one that requires inter-professional cooperation. For the general social good, members of every profession dealing with the developmental problems of children must cease entertaining petty jealousies. Concerted action again is required.

Table I is the distribution of the number of children wearing glasses. Thirty-two, or 25.4% of

the population, had previously had their eyes examined by an eye specialist.

**Table I**

**Summary of Incidence of Children Wearing Glasses**

| Status | | f | % |
|---|---|---|---|
| Wearing glasses | | 16 | 13.1 |
| All the time | 15 | | |
| Reading only | 1 | | |
| Not wearing glasses | | 106 | 86.9 |
| Total | | 122 | 100.0 |

## Summary

1. Only 25% of the population studied had been previously examined by a specialist in seeing.
2. Only 13% of the population were wearing corrections at the time this study was initiated.
3. The findings suggest:
   a. Need for more nearly adequate health service.
   b. Need for school health workers with special professional preparation that enables them to deal effectively with *school* health problems.
   c. Need for teachers with professional preparation that enables them to cooperate effectively with school health workers.
   d. Need for a program of parent education in this area.
   e. Need for elimination of petty inter-professional jealousies so that a cooperative attack can be made.
   f. Need for ever better prepared specialists who are willing to make those personal sacrifices necessary to keep abreast of the progress of science.

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# Part XXII

## Summary and Conclusions

The chief purpose of this study was to survey the seeing problems of one fifth grade population. The problem was approached in four ways: first, a battery of visual survey tests was given; second, a complete visual analysis was made; third, a cycloplegic examination was made; and fourth, one intelligence test and one reading test were administered for the purpose of determining reading achievement in terms of mental ability. In addition to the presentation of the data on the visual problems of fifth grade pupils, information was secured on the relationship between reading achievement and seeing handicaps.

Recent studies on the psycho-physiology of seeing have contributed new ideas, if not new concepts, of visual problems. More emphasis is placed on binocular vision, and more attention is given to near-point seeing problems. The mere mechanical refractive approach to the visual problems of both children and adults has proved to be quite inadequate. At least from the point of view of prevention, the sheer mechanical, or anatomical, approach is characterized by unmistakable elements of futility. In short, it appears that the dynamics of seeing merit consideration in the prevention and correction of seeing difficulties.

In both industry and the schools, greater significance is being attached to binocular vision. Industry is confronted with worker efficiency at certain near-point tasks as well as with laws regarding workmen's compensation. Educators and school psychologists are more concerned today about vision as it relates to the use of stereoptican slides, to reading problems, and the like. As a result, it is being discovered that a significant percentage of the population at all age levels is in need of corrective work. During the recent army examinations, a remark was made by one of the examiners that if we hold to present rigid requirements three-fourths of the applicants would not pass due to faulty vision. It is fitting that we begin to investigate the seeing problems of children with the idea of prevention in mind. The question is now being asked, "How can these functional seeing difficulties be prevented?"

### Findings

The data on each finding taken in this study have been presented and summarized in previous sections of this report. Table I is a summary of certain functional and cycloplegic findings.

### Cumulative Effects of Certain Findings

When visual acuity alone is considered, the findings in this study agree in general with the findings from previous investigations. If visual acuity, as measured by means of a Snellen Chart, was the only factor in vision requiring consideration, then referral and correction would be a relatively simple matter. As findings are added to the referral routine, more cases are referred. Table II shows the cumulative effect of using certain additional tests. For example, 26.55% of 113 cases were referred on the basis of visual acuity for distance. Additional findings from other tests increase the referrals, so that when the six findings were used 66.37% of the cases were referred.

**Table II**

**Cumulative Effects of Certain Findings**

**(113 cases)**

| Finding | f | % | % |
|---|---|---|---|
| 1. Visual Acuity at distance | 30 | 26.55 | 26.55 |
| 2. Visual Acuity at near | 2 | 1.77 | 28.32 |
| 3. Near Point of Convergence | 9 | 7.97 | 36.29 |
| 4. Faulty Ocular Motility | 4 | 3.54 | 39.83 |
| 5. Symptoms Inventory | 25 | 22.12 | 61.95 |
| 6. External Pathology | 5 | 4.42 | 66.37 |

### Lens Corrections

The following criteria, admittedly inadequate, were used to determine the need for a lens correction:

1. An esophoria of 5△ or more through the manifest at 16 inches.
2. Less than 20/20 in either eye.
3. Less than 14/14 in either eye at near.
4. Astigmatism of .75 D. or more.
5. Simple hypermetropia of 2.00 D. or more;

**Table I**

**Summary of Certain Functional and Cycloplegic Findings**

| | F | M | S.D. | S. E. of M. |
|---|---|---|---|---|
| 1. Near-point of Convergence | 121 | 4.79 cm. | 0.25 | 0.02 |
| 2. Habitual Lateral Phorias | | | | |
| At 20 feet | 116 | 0.09 Exo | 2.57 | 0.24 |
| At 16 inches | 115 | 2.48 Exo | 4.75 | 0.44 |
| 3. Induced Lateral Phorias | | | | |
| At 20 feet | 117 | 0.19 Exo | 2.27 | 0.21 |
| At 16 inches | 116 | 2.81 Exo | 1.71 | 0.16 |
| 4. Prism Convergence (Adduction) | | | | |
| Blur: Distance | 116 | 7.44 | 2.55 | 0.24 |
| Break: Distance | 116 | 21.22 | 5.83 | 0.54 |
| Recovery: Distance | 116 | 7.19 | 4.97 | 0.46 |
| Blur: Near | 116 | 18.25 | 6.25 | 0.58 |
| Break: Near | 116 | 21.66 | 5.61 | 0.52 |
| Recovery: Near | 116 | 6.40 | 6.58 | 0.61 |
| 5. Prism Divergence (Abduction) | | | | |
| Break: Distance | 116 | 7.10 | 3.20 | 0.30 |
| Recovery: Distance | 116 | 3.29 | 2.19 | 0.20 |
| Blur: Near | 116 | 17.95 | 4.45 | 0.41 |
| Break: Near | 116 | 21.52 | 3.77 | 0.35 |
| Recovery: Near | 116 | 12.47 | 6.44 | 0.60 |
| 6. Vertical Ductions: Distance | | | | |
| Supraduction | | | | |
| Break: Right | 112 | 2.78 | 0.84 | 0.08 |
| Recovery: Right | 112 | 1.17 | 0.43 | 0.04 |
| Break: Left | 112 | 2.55 | 0.82 | 0.08 |
| Recovery: Left | 112 | 1.20 | 0.47 | 0.04 |
| Infraduction | | | | |
| Break: Right | 112 | 2.04 | 0.73 | 0.07 |
| Recovery: Right | 112 | 0.94 | 0.42 | 0.04 |
| Break: Left | 112 | 2.15 | 0.91 | 0.09 |
| Recovery: Left | 112 | 0.98 | 0.48 | 0.05 |
| 7. Vertical Ductions: Near | | | | |
| Supraduction | | | | |
| Break: Right | 113 | 3.37 | 1.47 | 0.14 |
| Recovery: Right | 113 | 1.62 | 0.87 | 0.08 |
| Break: Left | 113 | 3.21 | 1.58 | 0.15 |
| Recovery: Left | 113 | 1.66 | 0.93 | 0.09 |
| Infraduction | | | | |
| Break: Right | 113 | 2.70 | 1.53 | 0.14 |
| Recovery: Right | 113 | 1.31 | 0.94 | 0.79 |
| Break: Left | 113 | 2.52 | 1.58 | 0.15 |
| Recovery: Left | 113 | 1.21 | 0.76 | 0.07 |
| 8. Retinoscope | | | | |
| Fixation, 20 feet | 118 | +0.70 | 0.97 | 0.06 |
| Fixation, 20 inches | 118 | +1.91 | 0.88 | 0.06 |
| Fixation, 40 inches | 118 | +1.36 | 0.97 | 0.06 |
| 9. Subjective | | | | |
| Spherical component | 121 | +0.42 | 1.15 | 0.02 |
| Cylindrical component | 121 | —0.21 | 0.21 | 0.04 |
| 10. Cycloplegic | | | | |
| Spherical component | 115 | +1.10 | 1.37 | 0.09 |
| 11. Cross-cylinder | | | | |
| Dissociated | 115 | +1.78 | 0.98 | 0.07 |
| Binocular | 115 | +1.44 | 0.98 | 0.07 |
| 12. Amp. of Acc. | | | | |
| O.D. | 116 | 11.69 | 2.67 | 0.25 |
| O.S. | 116 | 11.66 | 2.64 | 0.24 |
| O.U. | 115 | 8.37 | 2.76 | 0.26 |
| 13. Pos. Rel. Acc. | 115 | 4.84 | 2.34 | 0.22 |
| 14. Neg. Rel. Acc. | 114 | 2.16 | 0.63 | 0.06 |

or of .75 D. or more with symptoms unless contraindicated by exophoria.

6. Acceptance of any amount of minus lens (binocularly).
7. Anisometropia of .75 D. or more.
8. Hyperphoria of 2△ or more at near or far.
9. Heterotropia.

The criteria used for determining the need for lens correction yielded a substantial number of near-point problems. In terms of the criteria, 37.6 per cent was placed in the "no glasses" category. Of this group, a number were excluded by the one criterion dealing with adductive fatigue (convergence insufficiency). Criteria are being established to determine the need for orthoptics among those cases in both the "glasses" and "no glasses" categories.

Data on the need for lens correction are summarized in Table III.

**Table III**
**Summary of Data on Need for Lens Correction**

| | f | % |
|---|---|---|
| No glasses | 44 | 37.6 |
| Glasses | 48 | 41.0 |
| Glasses for near only | 25 | 21.4 |
| Total | 117 | 100.0 |

### Conclusions

Within the limitations of this study, the following conclusions appear to be valid for the fifth grade population studied:

1. There appears to be a high percentage of seeing difficulties revealed among school children when a thorough visual analysis is made.
   a. The small percentage of the population wearing corrections indicates a need for improved school health examinations.
   b. Approximately one-third of the population studied should have been referred on the basis of the Snellen chart findings.
   c. In approximately five per cent of the population there was evidence of intra-ocular pathology.
   d. There was evidence of external pathology (which was easily detected and for the most part with no serious implications) in approximately one-fourth of the population.
   e. Less than two per cent of the population were squint cases.
   f. The use of a cycloplegic did not make it possible to determine additional evidences of intra-ocular pathology in the population studied.
   g. There was no substantial difference between the cyclindrical findings revealed by means of the cycloplegic and those discovered by means of the subjective method.
   h. It was found that the subjects could accept approximately 0.50 D. more plus under cycloplegia than they could in the subjective finding.
2. A substantial proportion of the fifth grade population is aware of seeing difficulties.
3. There appears to be a significant relationship between reported symptoms and performance on visual analysis tests. On the other hand, a substantial percentage of the fifth grade children have seeing difficulties of which they are not aware.
4. There appears to be no significant relationship between achievement in reading, in terms of mental capacity for achievement, and the summation of the visual factors appraised in this study. However, this should not be interpreted as meaning that ocular comfort and visual efficiency are not desirable pre-requisites for sustained reading activities.

### Implications

The findings of this study indicate clearly the need for additional studies on the seeing problems of individuals at various age levels. These problems should be defined by means of comprehensive visual analysis techniques. Studies reported heretofore have been cursory in nature.

If the findings reported herein are verified by subsequent studies, then serious thought should be given to preventive measures. It may become necessary to appraise the near-point seeing tasks imposed upon elementary school children. Sustained reading activities may produce visual inefficiency, especially among school children.

Evidences of toxic conditions uncovered in this study lead to the conclusion that the relationship between health factors and efficient seeing should be studied. In the larger sense, seeing is a psychophysiological process. Strictly anatomical concepts of seeing appear to circumscribe thinking and practice.

# Part XXIII

## Approaches to the Study of Vision Problems

Thinking and procedures in actual practice usually are found to lag behind those in specialized laboratories and research units. In the field of professional education, practices (such as regimented use of basal textbooks and the use of sheer repetitive drills) have been challenged since 1860. It is small wonder, then, that one finds in some school health units and in the offices of some "eye" specialists the procedures based on assumptions and prejudices that have long been discarded by those who are provided by society with the opportunity to investigate and reflect on specific problems. This lag between research and practice should not necessarily produce discouragement; instead it should challenge the best efforts of those who are in positions of leadership.

Time produces rapid changes, but the development of a substantial and well-founded approach to a given problem is a long, slow evolutionary process. Real progress is achieved at the expense of tremendous amounts of time and energy. Yes, sometimes this is done at the expense of a professional reputation. Leaders with a refined sense of social values must validate their conclusions and dare to present them. In addition, opposition to re-interpretation must be expected. Man is fundamentally conservative in changing his patterns of behavior, because change necessitates re-orientation, and re-orientation requires a re-appraisal of basic assumptions, reflective thinking, insight into scientific procedures, and, above all, a willingness to see fallacies in old concepts and to adopt a pragmatic view of the new considerations. An opposition to revised formulations is necessary so that every step shall be challenged and critically appraised. All humans are likely to err, but regression exists in the absence of progression.

To reduce this lag between research and practice, to provide society with the fruits of science through alert practitioners (teachers, doctors, or lawyers), and to study the means of implementing new findings, continued study is mandatory. Recognizing this need, many diverse professional groups have developed programs of study at the post-school, or post-graduate, level. This appears to be one of the most effective means of insuring benefits to the society which is supposed to be served. When any one professional group assumes its full obligations to mankind, it is recognized and rewarded by demands for that service.

Not the least of the values accruing from the combined study efforts of the members of a given profession is that of the relating of scientific endeavors. The contributions of men and women in the many professions come to fruition, in the larger sense, to the degree that co-operative efforts are made to relate allied fields of endeavor. Human knowledge cannot be isolated and classified into clean-cut categories. Neither can a given profession serve best by following a policy of isolation. The debt of a profession to society can be paid only by co-operating with all those agencies for the promotion of human welfare and happiness.

For the educator there is no possibility of dividing the learner into the mental, emotional, and physical categories. These are only labels given to certain facets of a whole. This does not mean, however, that a teacher has the obligation to master all information pertaining to the whole child. Quite the contrary, the educator must be sensitive to these facts of learning problems, and he must depend upon inter-professional co-operation. Enough attention has already been directed to the total needs of the learner to make clear the necessity of collaboration.

Through professional study-groups and inter-professional cooperation, mutual problems can and will be identified. Even a cursory view of specialized areas of study indicates a common basic type of thinking. Mechanistic psychology which has

dominated educational practice for generations is slowly being uprooted and new growth in terms of Gestalt, configuration and/or organismic principles is being substituted. Structural, anatomical, or mechanistic concepts of certain vision problems are gradually being discarded in favor of psycho-physiological, or functional, concepts. In short, many areas of human endeavor (such as in the physical and social sciences) are being transformed by changing the emphasis from *static* considerations, in which the structural entities are stressed, to the study of *dynamics*. The trend in this direction is unmistakable. This shift in emphasis is producing a common ground for cooperation and is opening new vistas of research possibilities.

### Eyes and Seeing

Interchange of professional views, opinions, concepts, and the like is made difficult by semantic difficulties. Labels used to indicate certain word-fact relationships cause unending confusion because the referrent doesn't stay put. Furthermore, shifts in meaning brought about by changes in word-word relationships frequently lie fallow because the reader or listener has a low level of semantic sensitivity. Skepticism or unwarranted conclusions are likely to arise when semantic rapport has not been established.

In discussions on vision problems, one of the chief misunderstandings arises from wrong identifications regarding the labels *eyes* and *seeing*. The label *eyes* is used in discussions of *structure;* the label *seeing* is used when referring to vision in *operational* terms. The teacher, the school psychologist, the nurse, or the "refractionist," tests *seeing* as a functional thing, not *eyes* as structures. In fact, they do not even so much as look into an eye. Excluding pathological cases, the learner is referred on the basis of certain screening tests of seeing to the specialist for the diagnosis or the analysis of seeing difficulties! Sometimes cooperation between the school worker and the specialist is frustrated by the misapprehension of the specialist who believes that *eyes* are being *examined*. In most instances, educators are vitally concerned about how well their students *see* and are only remotely, if at all, interested in possible faulty eyeball *structure*. A matter of sheer terminology—an abstraction—can be an insurmountable barrier to mutual understanding.

### Emphases

A review of the literature on vision reveals contrasting concepts. One view emphasizes structure as a factor; the other, function. The first is the older view; the second is a product of collation. The structural emphasis is mechanistic; it was developed at a time when man was chiefly concerned with the study of parts. The functional, or psycho-physiological, emphasis is discussed in operational terms. While the study of anatomy was and is essential, scholars soon learned that behaviour could not be explained entirely in terms of structure. This encouraged the development of areas of study dealing with dynamics—with learning, motivation, etc. Not the least of these areas is psychology. With many problems undergoing redefinition, it is only natural that contrasting emphases should result.

Both structure and function must be considered; structure in relation to *eyes* and their muscles, and function in relation to *seeing*. It is not a matter of complete acceptance or rejection of either approach; rather, it is a matter of emphasis. There are few, if any, substantial students of vision problems who would confine their procedures to one approach.

Notable among those students dealing with psycho-physiological concepts of vision are De-Prangen, Lancaster, and Skeffington and his associates. Their work is backed by evidence accumulated in neurological and psychological laboratories as well as by clinical evidence. The full impact of this approach probably will not be felt until more research is done and the findings from allied fields have been translated and brought to bear on the problems.

The following is an attempt to contrast briefly the concepts and basic assumptions necessary for an understanding of the issues.

#### 1. Concept of Vision

Those entertaining mechanistic concepts of vision imply that seeing is done with the eyes. On the other hand, the functionalist emphasizes seeing as a psycho-physiological process, as involving the nervous system.

Patterns of seeing are learned, as one learns to talk and to walk. They are learned to meet the seeing needs of the organism in the environment in which it is placed. Structure may be altered by pathology, but singleness and clearness of vision are demanded by the mind. Patterns of accomplishment are altered in these terms somewhat as the individual adjusts his pace to the length of his legs or his speech to his organs of production.

#### 2. Identification of Vision Needs

The structuralist *refracts* to correct a structural anomaly; that is, to correct the length of an eye ball for the purpose of creating a state of emmetropia. The functionalist *analyzes interferences in binocular functions*. It is maintained that while the eye may, in one sense, be a structural entity, it is not a functional entity.

Visual needs sometimes have been discussed in terms of certain concepts of myopia, hyperopia, "weak" muscles, etc. Myopia was used as an antonym of hyperopia; tests were made by means of static or "at rest" measures; the dynamics of seeing were incidental considerations; orthophoria and emmetropia were the goals of the refractionist; and lenses were used to reduce "effort." While re-

cent concepts of the identification of vision needs should not remain unchallenged, older concepts are being challenged on the basis of results.

In the past, considerable attention has been given by structuralists to weak and strong muscles. Excluding paralysis and paresis, the functionalist can demonstrate that muscles are usually strong enough to move the eyes in their orbits and that interferences in binocular functions should receive major consideration. In short, emphasis is now being placed upon "patterns of seeing" through the analysis of relationships between functions.

**3. Adequacy of Far Point Tests**

For those who place emphasis on structure, far-point tests are sufficient. They assume that behaviour at the near-point can be predicted on the basis of far-point findings. Fairly low correlations between far-point and near-point findings have caused others to take a different stand, and quite justifiably so. In view of this, they believe that tests should be made at both far point and near points. Deviations from "structural" expecteds, then, have significance in the analysis routine.

**4. Adequacy of Monocular Tests**

In terms of structural concepts, monocular tests of vision are adequate. Unfortunately, however, *singleness* of image must be considered in relation to *clearness* of image. Hence, the functionalist emphasizes the need not only for tests at various working distances, but also for *binocular* tests.

**5. Concept of Discomfort**

The mechanist assumes that discomfort is caused by effort to compensate for faulty structure, such as an aberration in the length of the eyeball. Since emmetropia is unusual, eyes are shorter or longer than "something." (This "something" has gone undefined.) The eye is perfect if light can be brought to a sharp focus on retina; therefore there can be no functional difficulty. On this basis, he concludes that those with ocular discomfort are neurotic because the emmetrope can have no trouble. Once the individual has been labeled, the problem is solved!

The functionalist views ocular discomfort as a projection. A psychological response has been brought into play. To analyze the problem, a study is made of interferences in the binocular functions. An attempt is made to identify faulty patterns of seeing; relationships between binocular functions are investigated. Observations and data appear to indicate that it is the emmetrope and the individual with a "low refractive error" who is most likely to have ocular discomfort. Although more evidence is needed on this point, it does appear that the burden of proof is on those who entertain the first view.

**6. Test Findings**

The mechanist views his tests as measures of structure or structural anomalies. This may or may not require the taking of test findings when the eyes are supposedly in a "state of rest," but the emphasis is on static refraction. The functionalist believes his tests are indexes to the behaviour of a living organism at a given time and under a given set of conditions. In this instance, the emphasis is on the dynamics of seeing. The eye is a part of the body; hence, seeing behaviour is conditioned by body tone, etc.

**7. Exact Refraction**

The mechanist assumes that an exact refraction is possible and that it is the chief, if not the only, means of meeting the seeing needs of an individual. The functionalist emphasizes the need for a differential diagnosis, a differentiated analysis routine. Since a human organism is a dynamic rather than a static quantity, exact measurement of mechanical disparity probably is neither possible nor even essential. He produces data to show that where exact refraction has been assumed as the basis for correcting certain types of difficulties, the problem has not been solved.

**8. Prevention**

Those entertaining mechanistic concepts of vision have not made clear their proposals for the prevention of visual difficulties. If visual problems result only from faulty structure, then, one would be forced to conclude that variations in structure among individuals preclude possibilities of prevention. Emphasis, therefore, would necessarily be placed on therapeusis rather than prophylaxis. Prevention of visual difficulties is the keystone of the program suggested by those who emphasize the dynamics of seeing, or seeing as learned.

**9. Correction**

On the basis of structural concepts of vision, glasses, medication, and surgery have been used as the chief means of caring for visual needs. Surgery and medication are used in dealing with eyes, glasses when dealing with seeing. In addition, medical attention may be required to re-establish a balance of body functions which may be reflected in visual difficulties. Since the organs of seeing are a part of the body, attention to body functions would appear to be justified.

Progress, however, has been made beyond this level of thinking and practice. This progress has led us further into those intangibles that contribute to professional understandings of the dynamics of seeing. It is in this area that the neuro-physiologists and the physiological-psychologists are contributing their findings and conclusions. Their data on seeing has indicated the necessity of considering seeing as learned. This has shifted the *emphasis* in the study of visual problems. As a result, the educational psychologist has been presented with another area in which to apply his findings.

The specialist in seeing, therefore, has been introduced to the terms *learning* and *re-education.*

If seeing patterns are learned, then faulty patterns can be corrected, in part at least, by re-education. This concept has made it necessary to re-evaluate analysis procedures and to re-appraise the interpretations of those findings. Here, again, emphasis has been shifted from considerations regarding a "static" eye to the dynamics of seeing which implies learning.

In operational terms, glasses are not thought of as a means of correcting a faulty structure. Instead, they are considered as a means of changing the character of the light stimulus; prisms to change stimulus to adduction; spheres, to focus. In either case, the specialist is concerned with changes induced in the related function. Faulty patterns of seeing then may be corrected not only by changing the stimulus by means of glasses but also by re-orientation of the individual through re-education. In short, the functionalist is concerned with the development of visual readiness for certain seeing tasks in which glasses may be a part. This type of thinking has lead a significant number of "refractionists" to consider re-education (sometimes called orthoptics) as a part of office practice. In order to do so, they have become students of learning problems. "Begin where the learner is" has added significance. Reconditioning *sequences* are studied; monocular responses are appraised before considering binocular responses. In short, motivation, systematic sequences, and the like are likely to become basic terms in the language of the specialist.

### Summary

The change in emphasis from mechanistic to functional concepts of vision has several implications for educators. First, educators and specialists in seeing can "talk the same language." A common ground for understandings of mutual problems has been laid. Second, school health programs are being revised. More nearly adequate means of screening out cases for referral are being accepted for the benefit of childhood. Third, possibilities of preventing certain vision problems are becoming apparent. In this respect, the specialist in seeing is placed in a different light; he is in a position to assist with the appraisal of school practices and of certain external conditions of learning. This shift in emphasis brings educators and specialists closer together and reveals new vistas of research possibilities.

It has been said that vision, like mathematics, was influenced by the physicists of the nineteenth century. But the *physics* of that time was predicated upon bases that have been revised. In short, all our basic sciences are being continuously reappraised and revised. Progress is made on all fronts of human endeavor.

The term structure itself is being used in a different sense by several research workers. In fact, it is being defined in functional terms in some areas. Whether or not the terminology is revised, progress is being made.

In regard to vision problems, educators, school psychologists, and industrial psychologists probably can be classified as pragmatists. They evaluate the work of specialists by the results obtained. By means of an increasing number of psychological tests, they are being equipped to appraise, in a functional sense, those results. All specialists in vision are issued a challenge to prepare themselves to render a modern professional service. They must not fail!

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# Appendix

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### The Pennsylvania State College
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